The Earth in Past Ages

4b.

THE EARTH IN PAST AGES

BY

SOPHIE BLEDSOE HERRICK

AUTHOR OF "CHAPTERS ON PLANT LIFE" ETC.

Illustrated

NEW YORK ·:· CINCINNATI ·:· CHICAGO

AMERICAN BOOK COMPANY

W. P. 10

CONTENTS.

ILLUSTRATIONS.

THE EARTH IN PAST AGES.

CHAPTER I.

WHAT IS GEOLOGY?

GEOLOGY is the history of the earth and of the various kinds of plants and races of animals that have lived upon it. · This history is not written in books—there were no human beings living to write them—but it is recorded upon the rocks in various ways. In places sand rippled by the tide has been covered over and preserved till it has hardened into stone. This is just as plain a story of some far-off day when a sandy beach lay along the sea and the incoming water threw it into ridges, such as you may see upon our sea-coast to-day, as if some one had seen it and written down a description of what he saw. In other places a piece of sandstone is pitted with holes made by a pelting rain. It does not need any written word to tell us when we find such a bit of rock that

there were rain-storms in those days. Here rocks are tilted up and broken, showing some great force underneath; and there they are rounded and worn, showing the action of water or ice. In the midst of a mass of rock laid open by the blow of a hammer we find delicate sea-weed, with every marking on the leaves as plain as if they had been pressed; or we may find in such a layer of rock laid open an exquisite shell or starfish. What need do we have of words to tell us that when that rock was only a sandy sea-bottom these plants and animals had sunk in the water, were covered over by new settlings of sand, and so preserved as you might preserve a shell in plaster of Paris, and that the sand had afterwards turned into sandstone?

There is this one thing that the world has learned very slowly to do, and that is to look honestly at nature to see what is there, and then to use their common-sense in finding out the true meaning of what is seen.

In the land of Egypt, for thousands of years, there have been lying, half buried in the sand, curious rocks, and temples covered all over with markings that no one could read. Tall monoliths, with strange charac-

ters carved upon them, pierced the blue and rainless air, offering their riddle to be guessed, but no one was able to read it. If you ever go to the Central Park in New York, you will see one of these monoliths, called Cleopatra's Needle, that stood for thousands of years in Egypt unread. Less than a hundred years ago a Frenchman named Champollion made a study of these signs. He worked long over them, and by the aid of a famous stone called the Rosetta Stone, which had upon it an inscription in three different languages, he discovered the clew to the signs on the stones, and at last could read them; and from what he found there he was able to write a history of the past in Egypt in a language that can easily be read.

In the same way these other strange writings upon the rocks, the shells and leaves and bones, left there by a life long passed away, had been noticed and thought queer, but had never been interpreted. Ovid, a Roman poet who lived in the days of Christ, tells us that he had seen shells on the mountain-tops, and land made by the action of the sea. The first person who ever gave to the world a true explanation of these things was the great painter Leonardo da Vinci. He lived four hundred years ago, and you have probably

seen some engravings from his celebrated paintings, "The Last Supper" and "Mona Lisa." A hundred years later another artist, Bernard Palissy, published a book in which he said that the "figured stones," as he called them, were the remains of beings that had once been alive and had been preserved in the sea-bottom. It is rather curious that these two men were not men of science. They were artists, who had trained their eyes to see and their minds to think about what they saw. For two centuries after this clew was offered them, the so-called men of science went groping about in the darkness, making foolish guesses and still more foolish arguments.

Other people since the days of Ovid have found sea-shells upon the tops of mountains, and have explained their presence in various ways. For a long time the Deluge was made to account for anything out of place in creation. When the shells and sea-plants and animal skeletons were buried under hundreds of feet of rock, the Deluge was given up, and other ideas were adopted.

In Greece, elephants' bones were supposed to be the bones of their old heroes; and Ajax, one of the warriors whom Homer tells about, was calculated, from a

fossil knee-bone, to have been twenty feet high. The early history of all nations is full of stories of dragons and giants and terrible monsters. These stories probably rose from the finding of immense or curious bones unlike those of any animal living at the time.

After these stories and legends came to be doubted, the bones still were there to be accounted for. Some writers called them "freaks of nature." One brought forward a very queer idea; he said that before God created the animals, he made a great many models and stored them in the earth (as models of machines are stored in the Patent Office at Washington). Among these models are as many "failures" as among the patents, apparently, for they were never followed by living animals. Of the shells found far away from water, it was said, as late as a century ago, that they had been brought from Rome or the Holy Land by pilgrims, and dropped far inland or on the tops of mountain-peaks.

But the world was not to be hoodwinked forever by such foolish suppositions. As the facts became more and more in number, the common-sense view of the subject grew, and this nonsense became less believed. It was quite two hundred years after Leo-

nardo had explained the meaning of fossils before the world generally accepted his explanations and learned to read the riddle of the earth aright.

Geology is not an old science. It is scarcely one hundred years old to-day. And some things are still unsettled and others unknown; but there are many things which are perfectly fixed and known, and about the rest we are learning every day.

What I want you especially to bear in mind is, that the causes which in the past have built up the crust of the earth, and have formed its continents and islands, systems of lakes and systems of mountains, are the very same that are working like changes now. Apart from the work of man, they are the same, though less violent, as time goes on. If you use your eyes, you can often see yourself these causes at work—the gradual washing away of land by the action of water, the crumbling of rock by the action of ice; and in parts of the world new islands have been thrown up by volcanoes, and new land formed at river-mouths. These you may not see, but they are going on now, and you may read the accounts written by people who have seen them.

In order that you may understand geology, I am

going to try to show you the things that are happening now by means of the same forces that fashioned the crust of the earth, for a great distance down, in the past. The forces that raised up our continents out of the depths of the sea, that built our mountain-chains, hollowed out the beds of our lakes, ploughed the channels of our rivers, and built up layer upon layer our solid beds of rock, and then wore them down into powdered rock or earth on which the plants and trees can grow and animal creation live—these forces in geologic times were what they are now, stronger and fiercer in the new-born earth, perhaps, but the same. And as we go along studying our present earth and its changes, we will look back to the past, and try to interpret the unknown by the known.

CHAPTER II.

THE CLEW FOUND IN THE ROCKS.

More than sixty years ago there lived in a fishing town on the north-eastern coast of Scotland a boy who afterwards became a very famous man. When he was only five years old, his father, who was a sailor, was lost at sea. His mother, though very poor, managed to send little Hugh to school, and there he learned a good deal from books; but if he had learned no more than to read and to write, he would probably have still been a great man, for in the mean time he had found something else worth more to him than many books. He had learned to read another language. He had found out that he had two eyes, and how to use them. The rocks about the Firth of Cromarty were waiting for just such a pair of eyes to read their open secrets. Thousands of boys had played about those rocks, and thousands of men had fished and spread their nets and loitered there, but no

one of them all had read the writing on the stones till Hugh Miller came.

The boy used to go down to the beach with his uncle Sandy when the tide was low, and look at the ripples left in the sand by the water. He would gather shells, half buried in the sand, and sea-weed lying upon it. His uncle had eyes that saw, too—it seemed to run in the family—and he helped little Hugh to see the wonderful life of the sea-shore, and to think about what he saw. These lessons, far more than anything he had read in books, helped him in after-life, though he was a great reader of books too.

When Hugh grew to be a tall, lanky boy he chose his work in life; he chose to be a mason. His work lay in a quarry near Cromarty, close by his beloved sea. One day, as the men were lifting up the great slabs of sandstone, Hugh saw some markings on the piece of rock laid bare. These were the old familiar ripple-marks in the solid stone—just such marks as he had often seen on the sandy beach (Fig. 1). He did not say, "How strange!" and then forget all about it. He began to think, and ask himself questions. Could it be that this was an old sea-beach?

How could it be, under those tons and tons of solid rock? The answer came to his questions after a while.

Strewn along the water's edge, washed up by the waves, were curious roundish pieces of limestone rock. One day, hammer in hand, Hugh strolled along the beach. He struck one of these lumps, and it broke open, showing embedded in part of the stone a creamy-white shell, beautifully carved, and showing tints of color like the pearly lining of many of our shells. Another and another of these stones were broken open (Fig. 2). In some of them he found scales of fish; in others, fern-leaves (Fig. 3); in others, again, bits of decayed wood—all in solid stone.

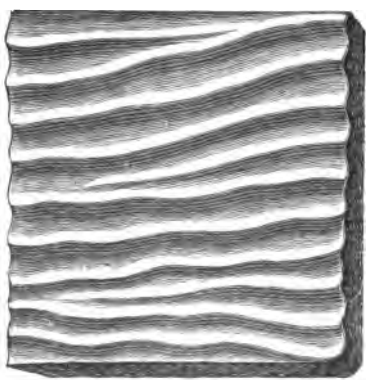


Fig. 1.—Slab of Ripple-marked Sandstone.
From Lyell's "Elements of Geology."

Now he could answer his questions. These things had once been alive. He had spelled out one word

Fig. 2.—SHELL IN THE ROCK (*Ammonite*).

from the tables of stone written upon by the finger of God himself. He had found the clew in the rocks, and he never rested until he had followed up this clew, and found, by examining the rocks themselves, and by reading about what other men had discovered, how the earth as it is had come into being.

If you have never carefully looked at the rocks of a railway-cutting as your car went through it, be sure that you do so the very first chance that you have. You will probably see that the rocks are in layers. Sometimes these lie level with the ground; sometimes they are very much bent or tilted (Fig. 4).

Fig. 3.—Fern-leaf in Stone.

To understand how these came to be so, we must understand some things which are very simple, but yet they are things that we would not naturally think of. What we call *earth*, or *soil*, is only rock finely powdered, mixed up with some of the dust from the dried parts of dead plants and animals. Earth is to rock about what the pulverized sugar you sprinkle over your berries is to the block-sugar your mother drops into your tea.

The surface of the earth was once rock which had no layers in it, like granite. Part of the round globe was covered with water, and a little of it was dry land. The beating of this old ocean's waves, the rain,

the air, all helped to grind the rock to powder, and with it muddy the sea-water. Take a tumbler of water, and into it drop a teaspoonful of finely ground earth. Your muddy water is something like the sea-water was then. Now watch, and you will see what

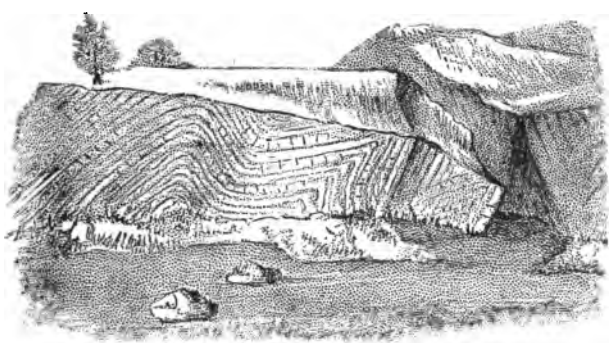


Fig. 4.—Tilted Layers in the Rock.

happened. The fine-powdered rock settled in the bottom of the sea-bed as the earth settles in your tumbler, and the first layer was made. Layer after layer was formed in this way. After a while "the spirit of God moved upon the face of the waters." A feeble life stirred in the bottom of the sea. Some very simple animals lived there, and we can find the curi-

ous shells in which they lived in those deep-down rocks. We know that plants must have come first, because plants are the only fairies that can turn rock and earth and water into the food that all animals need to feed upon; but the soft, delicate sea-weed had died and left no sign. The early animals, however, had hard, glassy shells, and when they died these shells sank to the bottom of the sea, and the next layer of powdered rock settled over them and preserved them—some of them until no

You can see how this would be, and that when we lay open the rocks, as Hugh Miller did with his hammer, we might find the shells. Here is a drawing of a bit of such earth that was turned into stone, with its corals and shell lying thick in the layer, which is half broken away (Fig. 5). This was picked up just below my house, on the shores of Newark Bay.

The work went on through thousands of years, the sea laying one upon another these wonderful beds of rock of different kinds. All this was not an *adding to* what already existed, but only a new arrangement, with some change in the character of the old materials already there. How this great earth came to be is one of the secret things of God. The Bible begins

with, "In the beginning God created the heavens and the earth." That is all we know. A guess here and there has been made as to how it was done, but no one knows, and no one probably ever will know.

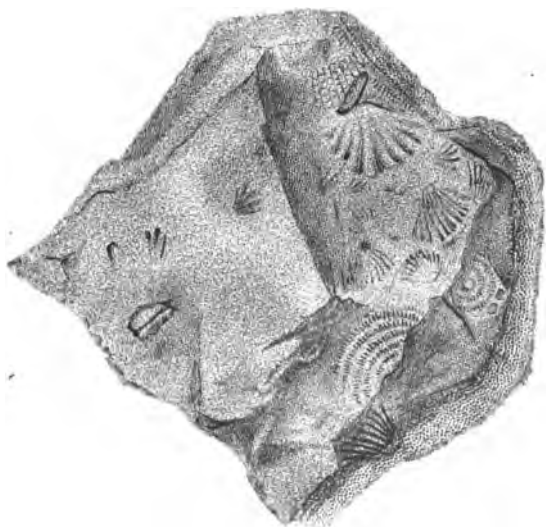


Fig. 5.—Shells in Broken Rock.

But we can tell the way the crust of layers was put on, because we can watch the same things going on now which went on thousands and thousands of years

ago. At the bottoms of shallow seas and lakes, at the mouths of rivers, in the coral islands of the Pacific, the earth is still a-building.

About a hundred years ago men began to be interested in these strange things found in the stones. They hunted up pieces of such stone, and wrote out all they could find about it. They arranged the facts, and called the new science geology, or the science of the earth.

It is very easy to see that if the seas had stayed all the while in the same place, with no disturbance going on, that the layers would have settled one on top of the other, according to age, the oldest being the lowest, and so on up. But you must remember that the earth was then, as it is now, part dry land and part water, though there was much less land in proportion then than there is now. It was only *under water* that the layers were formed. But there were other things at work besides this gentle wearing away of the rocks and building up of the sea-bottoms.

Long ago people believed that under the volcano of Ætna, on the island of Sicily, a giant was imprisoned, and that the trembling and cracking of the earth before an eruption were his struggles to get free. This

had a meaning in fact, though it was only a fable. Under the whole earth the giant fire has been imprisoned. When the crust of the earth was thinner than it is now, the giant's struggles cracked and bent it; sometimes the bottom of the sea would be suddenly lifted

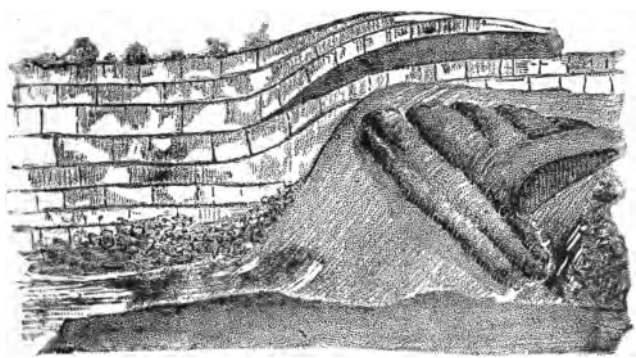


Fig. 6.—Level and Lifted Layers.

up, and the dry land would sink and be covered with the waters of the ocean (Fig. 6). On the left side of the picture are the level layers of rock, broken up so that they look like a stone wall. After a while we will see just why these are so broken. On the right-hand side you see the layers are lifted up by the cu-

rious, curly-looking rock which boiled up out of the earth beneath as lava comes out of a volcano. Whichever part of the earth happened to be under the water would be covered up with layers of mud, and in them plants and shells, fish and animals, would be buried, and their hard parts preserved. The other part, the dry land, would not be very much changed; the plants and animals there would die, and mostly be blown away as dust.

This history of the earth written upon the rocks, you can see, is not a very easy history to read. Its leaves were all scattered and torn and twisted, and the writing on them often rubbed out, and many of them lost. It had to be gone over again and again, in many different places and by many different men, before these stone leaves could be put together in the right order.

If these layers, or strata, as they are called, had remained just as they were placed, there would have been no way to reach them but to dig down to them, for twenty miles in some places, and that would have been impossible: nobody has ever been down, in the deepest mine, more than a mile. But the movements of the earth's surface, caused by the struggling fire

underneath, would tilt and break through the layers, and so the broken edges would be on the surface (Fig. 6), and the geologist could in places study the very bottom layers without digging down to them.

CHAPTER III

WATER.

Geology has nothing to tell us about how the great mass of the earth was first created. There have been many guesses, but they have never been proved to be correct ones. What we hope to find out by studying geology is how the surface of our earth came to be as it now is, with its seas and continents, mountains and lakes, rocky peaks and sandy deserts. This was the work of the same forces still busy in changing the face of the earth — the air above, the water on the surface, and the fires under the earth. So we will only go back to the time when the earth was a rocky globe, intensely hot inside, and covered with a universal sea, when the earth, as it moved round the sun, might be compared to a mighty drop of dew moving round a globe of glowing fire. We must get rid of all our notions of the world as it is now in order to go back in imagination to that

time. The earth was not beautiful then, the land was not adorned with trees and grass and lovely flowers, the air was not full of humming insects or swift-flying birds, nor the waters of darting fish and delicate floating sea-weed. It was a desolate waste of waters, a shoreless sea, whose tides, instead of rising and falling and breaking upon some sandy beach, followed the moon, sweeping unbrokenly around the globe. There were no blue skies overarching the wide waters, no fleecy clouds turning to gold in the sunsets. A heavy mass of leaden clouds covered the sky, and poured down into the hot seas hot rain-water day and night.

The only things in the world then were rocks and water, fire and air. But as the earth cooled, these forces, the moving water, the fire and the air, went to work and began building the continents and islands, and dividing up the waters into seas and rivers and lakes.

First came the fire and lifted up part of the earth's crust in its struggles; another part of the crust would go down, and into these low valleys the waters would collect, leaving the high, bare rocks standing up out of the sea. In this same way many islands and continents arose out of the sea. Next came the turn of the

air in the work of world-building. The air around the earth then was like the air now, only that it had a great deal more moisture in it, and the gas that comes from burning—called carbonic acid gas—than our air has. Such air as this has a very peculiar effect upon some sorts of rock: it slowly dissolves them; the waves of the sea, or the rivers pouring over the rocks, soon carry this dissolved rock, or earth, as it really is, away, and finally it settles in the ocean, forming layers of soil, which after a while become solid rock again. Then again these layers are uplifted, and again they become rotted partly away, carried off, and deposited. This is not mere guess-work. The world is not *done* yet; it is still a-making; just the very same things are happening now in various parts of the world as went on of old.

Islands have suddenly risen out of the sea, and men have seen them. At the mouths of great rivers and in the bottoms of ponds land is forming all the while. In some places, on the dry land, rock where it stands is rotted into earth, and gradually washed away by the rain; and where the weather is cold enough to freeze, this work goes on faster still. When you have an opportunity to examine a piece of brown stone,

Fig. 7.—Stratified Rock Cliffs at Brough.

used so much to build houses of, or as facings to brick houses, look carefully at it. You will be apt to find that there are on the surface loose flakes which you can rub away with your finger. Brown stone is full of little cracks and crevices and openings—the water soaks into these, and when it freezes it pries off the piece of stone above it; the ice, taking more room than the water, acts as a wedge. When the earth became cool enough to permit the rain to freeze, the rocks were in this way more quickly reduced to earth.

Just the same things went on in those days that go on now, only they were more violent. The cool crust of the earth was thinner; the inner fire, therefore, oftener succeeded in breaking its way out; the earth was more shaken; its crust was more torn and crumpled. There were, of course, more earthquakes, a larger number of volcanoes, and greater quantities of rain fell into wider seas.

See the picture of the Rocks at Brough. These cliffs have been slowly deposited in layers, and then lifted up by the fire, tilted as you see, as they were raised, and then again they have been worn away by the waters. In one place an archway has been made directly through them.

When the layered rock is lifted up, it is of course very much strained and cracked; the water gets into these cracks, and so does its work much faster. The Clett (Fig. 8) is a single pillar of layered rock standing up in the sea. The layers in this rock correspond exactly to those on the cliff near by, showing that it was once part of a great cliff reaching out into the sea.

Water does some very wonderful things when it falls over a precipice, and so makes a cataract. At Niagara the waters of the great lakes on their way to the sea fall over a high precipice of rock. This precipice is made of very hard rock on the top, while the layers underneath are much softer. The boiling of the waters, after tumbling over the high cliff, gradually wears away the softer rock below, then the upper layers stand out like a shelf, and over this the water falls. The rush and strain finally crack off the projecting shelf, and it breaks and falls; then again the softer rock is hollowed out; another shelf forms and is broken away. In this way the water-fall has worked its way backward for seven miles, as the rocks on each side of Niagara River show.

Great rivers like the Mississippi wash up earth

Fig. 8.—The Clett, Holborn Head, Scotland.

where they flow swiftly from high land to low land; when they come to a more level country they "slow up," and begin to drop the earth. Anything which makes the current run slower causes this sort of a deposit. Where two currents meet, as where the Ohio flows into the Mississippi, the two jostling together hinder each other, and in the contest earth is dropped, and a sand-bar is formed, making the river very shallow there. No matter how many times such a bar is removed, it comes again. Where the Mississippi empties into the Gulf the current spreads out, and so slows very much, and a great deal of earth is dropped. The jetties made by Captain Eads, of which you have probably heard, are banks built into the Gulf to carry the river currents swiftly out into the deep water, and there allow the earth to be dropped where it will not make the channel too shallow for ships to pass through easily.

Some rivers in India have built up their beds by dropping earth in this way all along through the low plains, until the bottom of the river's bed is higher than the country around. When the river overflows its banks, the fields beyond the high bed are flooded. Then, when the river sinks again, the water cannot

get back into the channel, and it lies on the fields and kills the crop.

Certain kinds of rocks are more easily dissolved by water and carbonic acid than others. When layers of different kinds of rock are exposed to the air, they crumble away very unevenly, and so make curious-shaped rocks, sometimes standing up like monuments in the sea or on land.

In rocks which are not dissolved in this way the water sinks into the cracks and flows away, doing very little work; but in limestone rocks, which the water does dissolve, the crack is washed larger and larger, till a cave is hollowed out in the solid stone down under the surface of the ground. The water goes on trickling and dripping from the roofs of these caves, and decorates them just as the freezing water in winter decorates the edge of your portico roof with icicles. I am sure you have often watched icicles form. As the rain fell from the roof, drip, drip, drip, each little drop left a little bit of itself behind frozen, and so an icicle gradually grew from these many drops.

But perhaps you were too busy looking at the sky to see if it were going to clear, to notice what happened underneath the icicle on the portico steps or

Fig. 9.—"The Cathedral," Luray Caves, Virginia.

the ground. There each drop left a little of itself again before running away, and a heap of ice was formed. Now, in the limestone caves just this sort of thing happens. The water, instead of leaving a little of itself *frozen* behind, leaves a little of the limestone that was dissolved in it behind, and great stone icicles are formed, which never melt. These are called stalactites, and below them the mounds of stone grow up, often far finer than the stalactites. The stalactite from above and the heap, or stalagmite, below often meet, and so form a pillar from floor to roof. Some of the best examples of these formations are found in the Luray Caves, Virginia (Fig. 9).

These limestone caves are sometimes so near the surface of the ground that the roof gives way, broken in by the roots of a tree, and down goes the living tree into a great hole in the earth. These are very common in the limestone section of Kentucky, and go by the name of sink-holes. In the Western country some of the rivers rush into such openings, and run underground for miles through cavern after cavern; these are called lost rivers; but far away, perhaps, the same river comes to light again, though it is not always recognized as the same.

CHAPTER IV.

THE REIGN OF FIRE.

You remember that besides the water and the air that helped to fashion our beautiful earth out of the globe of rock covered by a heated ocean which existed in the past, another force has been mentioned—fire. Fire is still working day and night in changing the world, but it is mostly underground.

Air and water are as much levellers as they are builders. If only these two forces had been at work, the mountains would gradually have been brought low, and the valleys exalted, till finally every rock and island would have been worn down and buried in the depths of the sea. The world would have returned to the condition it had been in thousands of years before, only it would have become cooler.

But the internal fires were there to upset all this gradual change. They were never at rest. Again and again the sea-bottom was lifted up and became

dry land, and the waters gathered together in new hollows.

Miners who go down into the earth for coal and iron find, after a certain distance, that it grows steadily warmer and warmer as they descend. If the heat of the earth goes on increasing at this rate, at thirty miles below the surface of the earth the heat would be so intense as to melt even iron or stone. As a matter of fact, things melt a great deal more easily when they are open to the air than when they are under pressure. Down deep in the earth the pressure of the rocks above is tremendous, and this gets heavier the deeper it is. So there is a battle between the heat and the pressure down deep in the earth, and whether the rocks there are melted or solid depends on which is the stronger. Some people think that all but a thin shell over the outside of the world is red-hot liquid; others think it is hot enough to be liquid, but that the pressure keeps it solid. However this may be, whenever, from any cause, the pressure is sufficiently lightened, the melted stone and cinders and steam come rushing out. Volcanoes are the chimneys by which they escape.

The cool crust of the earth is a great deal thinner

in proportion to the rest of the globe than an egg-shell is to the egg. In old geologic times the shell was thinner even than it is now. The fires then worked wonderful changes, the same in kind as they are working now, but much greater. The earth's crust—made of many layers of different kinds deposited by the water—was crumpled and torn and twisted in a most remarkable way.

The struggles of the internal fires often produce a sound and shaking — an earthquake. Suppose you were to lower a can of gunpowder (sealed up tight, and so arranged that it would go off in half an hour) into a pond. When the powder took fire it would explode, and as soon as the commotion reached the top of the water a wave would spread out from the point above the explosion. An earthquake is such an explosion, only it is underground; the earth is thrown into waves, but instead of rocking and moving off as the water does, the ground, being solid, is torn and broken, and if the shock is severe, houses are thrown down and people destroyed. Sometimes things are thrown straight up into the air by an earthquake shock; at other times they are shaken backward and forward till they fall in ruins. The movement of the

earth during a shock is at times a curious, twisting motion, which has been known to turn pieces of furniture around so that their faces were to the wall. Rows of trees have been found all twisted out of line, though still growing, after such a shock. We are apt to think of earthquakes as being very rare, and so they are with us; but in hot countries they are so common that it is probable that some part of the earth is quaking all the time.

Fig. 10.—Rock Veins.
From Hooker's "Mineralogy and Geology."

Sometimes, when the shock is not very severe, the earth cracks underneath, but the cracks do not quite come through. The melted stone then pours up and fills the cracks (Fig. 10), and hardens there. The intense heat of the melted stone often changes the rock through which it flows. Limestone, which is a rather soft stone made up largely of shells, is turned into marble in this way. Marble, then, is merely "cooked" limestone.

In Fig. 11 you see a cut through a part of the earth's

surface. At first, underneath all, was the melted stone; over this formed the layered rocks. Then the melted stone rose up, lifting the layers S S as it rose.

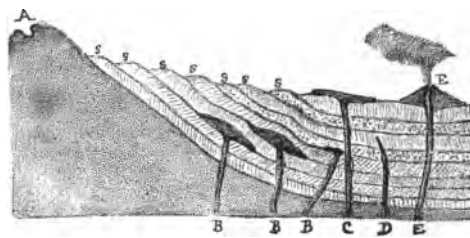


Fig. 11.—Section of the Earth's Crust.

As time went on, the air and water washed the layers from the top of the mountain, leaving it bare (A). After a while an earthquake cracked the earth, and more melted rock poured up. At B the cracks only reached part of the way up, and the lava, after rising to the top of the crack, spread out between two layers. At C it reached the top and flowed over the ground, making a solid slab of volcanic rock on top of the layered rock. At E the lava came out with such a rush that it built up a little volcano there.

Very often, when one stone is melted in this way, the crystals of another kind of mineral are enclosed

in it (Fig. 12). Here is another curious stone made by the fire. The lava cooled full of bubbles, and with these holes another mineral collected and hardened, as plaster of Paris fills a mould into which it is poured.

Fig. 12.—White Crystals of Feldspar.
From Lyell's "Geology."

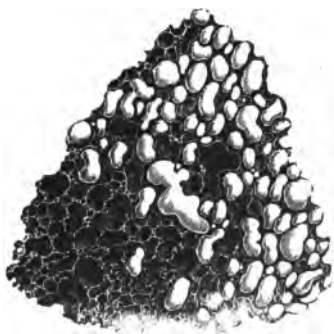


Fig. 13.—Scoriaceous Lava.
From Lyell's "Geology."

The moulds were made by fire, though it was a dissolved and not a melted mineral which filled them (Fig. 13).

A volcano, you know, is a mountain that sends out burning gases and lava and cinders. It is usually a high peak with a cup-like depression in the top, called a crater. The volcanoes of the world are found al-

most always near the sea, and nearly three-quarters of them are situated upon islands.

If you have a globe—or if you have not, a map of the world—put your finger on Terra del Fuego (the land of fire), at the very southern part of South America, then run it along the western coast of the two continents—the Andes and the Rocky Mountains being your guide—till you get to Alaska, where Asia and America almost touch; pass over to the Aleutian Islands and down by way of islands across the Indian and Pacific oceans back to Terra del Fuego again.

Fig. 14.

Fig. 15.

GRAPHIC GRANITE.

Fig. 14.—Section parallel to the laminæ.

Fig. 15.—Section transverse to the laminæ.

Your finger will have passed over most of the large volcanoes in the world. It is as if the earth's crust were cracked all around in this irregular line, that the

mountain-chains were the raised edges of this crack, and that the crack gave way every now and then, and through the broken places melted stone and gas and flames rushed out.

Some of the grandest volcanoes in the world are in the Pacific islands. One of the Sandwich Islands is nothing but an immense volcano with three craters. The island has been built up by the outpouring of lava, which gradually lifted it, craters and all, out of the sea. One of these craters, Mount Kilauea, is an immense wide pit, large enough to hold a city. The rocky plain at the bottom of the pit, when there is an eruption, breaks up and fills with lava. It is a wonderful sight to see these great lakes of red-hot melted stone boiling and bubbling like a great pot of boiling water, and the red-hot waves beating against the rocky shore, and spurting fountains of fire rising up here and there. In one eruption the weight of the lava was so great that it broke through the side of the crater, and ran down a river of living fire to the sea. When it met the water, great clouds of hissing steam spouted up, carrying the cooled and shattered lava with it.

The lava in Kilauea is often like clear glass, and

when the bubbles burst in the boiling lake it is drawn out into fine spun glass, which the wind collects in sheltered spots. The Sandwich Islanders used to call it Pele's hair, because they believed their goddess Pele lived under the crater, and caused its eruptions. After I wrote these words a curious thing happened to Kilauea: the bottom tumbled out of the crater, and the boiling, fiery lakes and fountains suddenly sunk in, and left it a great dark abyss.

In the sea near the coast of Greece, more than two thousand years ago, the crater of a great volcano was lifted out of the water. It made a sort of horseshoe island, part of the rim having been broken away. This island is called Santorin. In the curve of the bay enclosed by the horseshoe several volcanoes have burst up since, and are still sending out steam and vapor. The water around them is hot, and is colored orange by the iron and other things thrown out by the volcanoes.

The volcanoes in Europe, such as Ætna and Vesuvius, are different from Kilauea. Before an eruption loud noises are heard, an earthquake shakes the ground, and then comes a sudden outpouring of lava and cinders and smoke. In one of these eruptions,

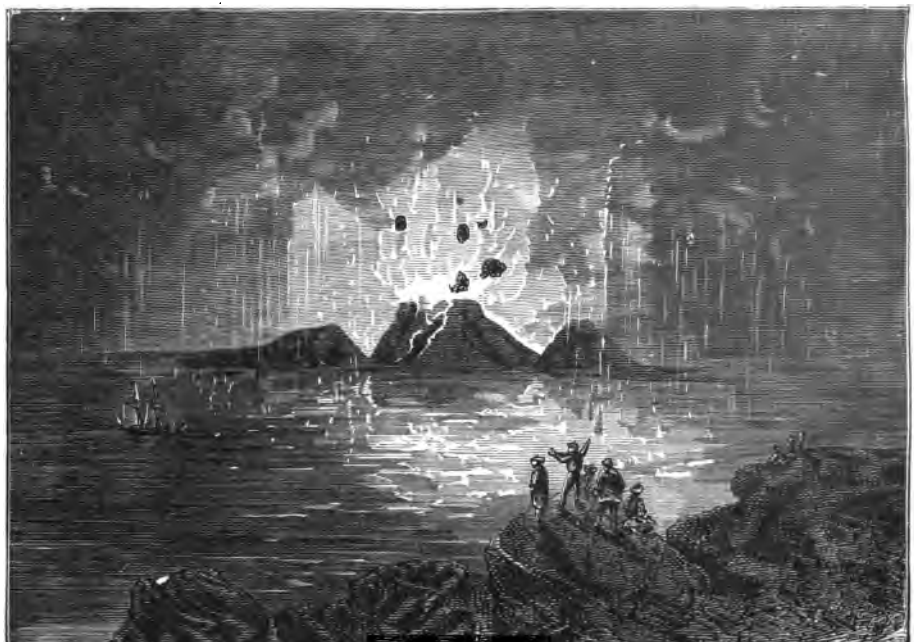


Fig. 16.—SANTORIN.

From Winchell's "Sketches of Creation."

soon after the time of Christ, two cities were buried by an overflow, one of mud and the other of cinders. A little more than a hundred years ago, in digging a well in a town that had grown up over the old one, the city was discovered. Imagine what a wonderful thing it must have been to walk those deserted streets, sealed up for nearly two thousand years, and find the houses, the baths, the libraries, almost uninjured! These buried cities, Herculaneum and Pompeii, were destroyed—as was thought until their rediscovery, about the middle of the eighteenth century—in the year 79. Some day you will read about them in Bulwer-Lytton's fascinating romance, "The Last Days of Pompeii."

In Mexico, in a peaceful district where there were fine cotton plantations, a hundred and thirty years ago lived a rich planter quietly cultivating his crops. Suddenly one day loud and terrible noises were heard underground; earthquake shocks were felt. This went on for two months, and then all quieted down. After a few weeks of quiet, the noises began again, the ground for about four miles swelled up in a great bladder five hundred feet high, which rose and fell, till finally a yawning gulf opened. Two rivers, which

before had flowed peacefully through the country, plunged into this opening and were lost. Thousands of little mud volcanoes burst up all over the plain, an immense crater opened, and poured out such quantities of red-hot stones and ashes that it built up a range of six mountains. One of these is a volcano, called Jorullo, which has been active ever since.

CHAPTER V.

FIRE AND WATER.

The sea along the western coast of Scotland is filled with numberless islands, which look on the map as if they might have been broken from the solid land. One of these is a tiny island lying close in the embrace of a larger one. Though it shows as a mere speck on the map, this little island of Staffa is known the world over for its wonderful natural formations. On the edge of the sea, rising direct from the water, is the well-known Fingal's Cave (Fig. 17). The regularity of its formation is so remarkable that it is hard to believe it to be a work of nature. Lofty columns of regular shape stand up out of the sea, built up, it would seem, of block upon block of solid stone carefully chiselled and as carefully laid upon one another.

On the northern coast of Ireland, at the point which is nearest the Scottish coast, is another wonderful as-

semblage of these columns, roofless, and running out into the sea, called the Giant's Causeway.

An old story makes these two wonders the ruins of castles built and inhabited by two unfriendly giants.

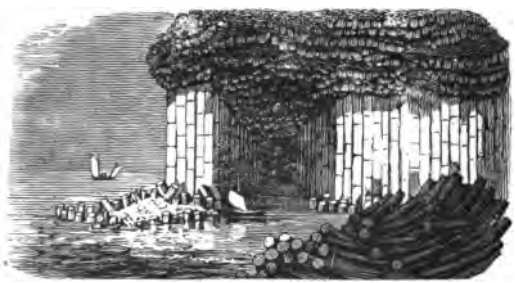


Fig. 17.—FINGAL'S CAVE.

The cave has received the name of the Scotch giant, Fingal. There are many old poems, sung among the Highlanders in the far past, of which Fingal is the hero; but we now know that no man's or giant's hand helped to lift these great blocks of stone one upon the other. They were built up by the fires under the earth. The melted stone poured out of the volcanoes above and spread over the land, and there, as it hardened and cooled, split up into great crystals, or columns. The water dashing for thousands of years

against them washed away the earth around and the broken fragments, but was dashed back again by a few of the hard, unbroken columns, and so were left Fingal's Cave, the Giant's Causeway, and other formations like these.

Too long ago for you even to imagine it, there was a great bridge of these columns reaching from Scotland to Ireland; the Giant's Causeway was one abutment, and Fingal's Cave another. In the thousands of years that have passed since, the rest of the bridge has been swept away and destroyed, with only here and there an island of columns between to tell the tale.

These rocks—hardened volcanic rock—are called basalt. They are not the only things which in drying contract and split into crystals. Take some common starch, dissolve it in water, and let it gradually dry. When it is perfectly dry, you will see that the sheet is full of quantities of fine cracks; loosen it from the plate, and you will find it all in crystals. Sulphur or salt will crystallize in the same way. Few things, however, split up as regularly as basalt does.

Sometimes where there has been a wide crack in the older rocks the melted basalt has run into and filled

the crack. In that case the stone as it hardened split up the other way, and instead of columns it looks like piles of logs. On the coast of Lake Superior there is a remarkable instance of this; the surrounding rock has worn away, leaving the hard basalt lying like a carefully arranged pile of cord-wood.

The great central fires of the earth are constantly at work, sometimes acting with shocks, and sometimes quietly and steadily changing the face of the earth. In India, seventy years ago, one of these sudden changes took place which was very remarkable. There was an earthquake shock, and a great piece of land fifty miles long and sixteen broad was suddenly lifted up ten feet higher than the country around, and there it has stayed, with a straight wall around the edge called by the natives "Ullah Bund," or "God's Wall," from the mysterious way in which it arose.

Without any earthquake shock or sudden movement continents are in some places slowly sinking and in others as slowly rising. It might seem as if it were the waters which were rising or falling, but a moment's thinking will show you that this cannot be so. Water soon comes to a level; and as there is

FIG. 18.—TEMPLE OF SERAPIS.

nearly the same quantity in the oceans all the while, it must be the land that is changing.

There was, a great many years ago, before Christ came into the world, a temple built on the Gulf of Baiæ, near Naples (Fig. 18). Three pillars of this temple are still standing, though they have seen many ups and downs since their building. The original pavement was of beautiful mosaic, and so well built that it still remains, though the earth on which it stands slowly sank for many years. About two hundred years after Christ a new floor was laid *six feet above* the old one, showing at that time how much the earth had sunk. Down, down the pillars went into the sea, till they had sunk twenty-six feet. Then came a terrible eruption of volcanic lava, and the temple was lifted bodily more than twenty feet, the pillars still standing upright. Twenty-six feet above the first pavement, and for twelve feet below that line, the pillars have been fairly pitted by some small sea-animal which had burrowed into the marble when it was under the sea. The story of the temple's travels is written on the face of the pillars. Now the temple is again slowly sinking at the rate of an inch a year.

Our own continent is tilting up in some places and

sinking down in others. The Florida coast is sinking, the North Carolina coast is rising. Near Boston the land is rising, and Greenland, for six hundred miles, is sinking so manifestly that the Greenlanders have learned not to build their huts close by the sea. An island in the Gulf of St. Lawrence is gradually tipping; its southern coast is dipping down and its northern rising into high bluffs.

The water and the fire in doing these mighty works, in gradually turning and tilting continents and islands, and wearing them down again, do not forget some smaller duties in the way of carving and ornamenting and beautifying the earth.

There is no country in the world which has more wonderful hot springs than our own. The hot water, filled with carbonic acid, which comes from the fires beneath the earth, has the power to dissolve certain minerals; these it brings up to the surface of the earth. The carbonic acid goes off in gas when it comes to the air, but the lime and other minerals are allowed to settle; there they harden and form a cup, from which the water drips down, forming limestone icicles or stalactites. Finally, cup after cup is formed in this way (Fig. 19), most wonderfully ornamented

In one place in Italy such a spring, which is at the top of a hill, has encased the whole hill in a layer of stone formed from its settlings.

In carbonated springs like those in Figure 19 most of the lime settles at the bottom, as earth will in water; but there is a still more wonderful kind of spring, which builds its own basin, and after a while makes itself into a fountain. Such a spring is called a geyser. These are very rare, because it takes so many different things acting together to form them. They are the children of fire and water. Geysers are found in Iceland, New Zealand, and our own Western country (Fig. 20). Those in the Yellowstone National Park, in Wyoming Territory, are perhaps the largest and most curious in

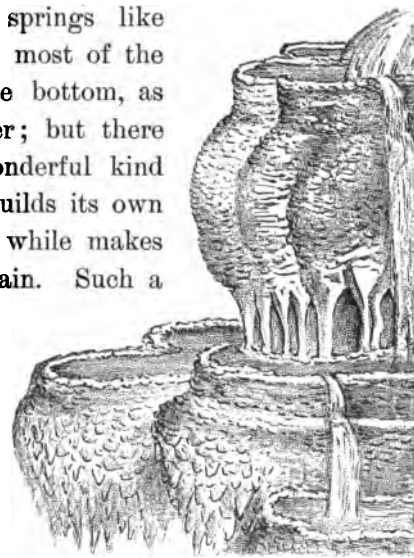


Fig. 19.—Carbonated Springs.

the world. Indeed, that region abounds with wonderful examples of Nature's handiwork, which must be interesting to all students of geology.

A geyser begins by being a little hot spring; it ends by being a natural fountain. Geyser water has been put into a basin, and allowed slowly to dry up. It is then found that the settlings from this water are not on the bottom, but that, as the water dried, it left a solid rim around the basin, and as it sank the rim broadened downward.

In the geyser water there is a white and glassy substance that, as it settles, builds a cup for itself; when the water overflows the cup, it naturally runs out of the lowest place. Here the solid rim is built up by the glassy silica till that gets higher; the water then shifts and flows over the lowest place left, building slowly the lowest places in the rim, till, instead of a cup, it makes a high tube with a mound of silica all around it.

Sometimes the water will lie quiet in the tube for a good while; but the fires beneath are turning water into steam, and when enough steam forms it lifts the water in the tube, in its struggles to get out, until finally the water is thrown up into the air violently,

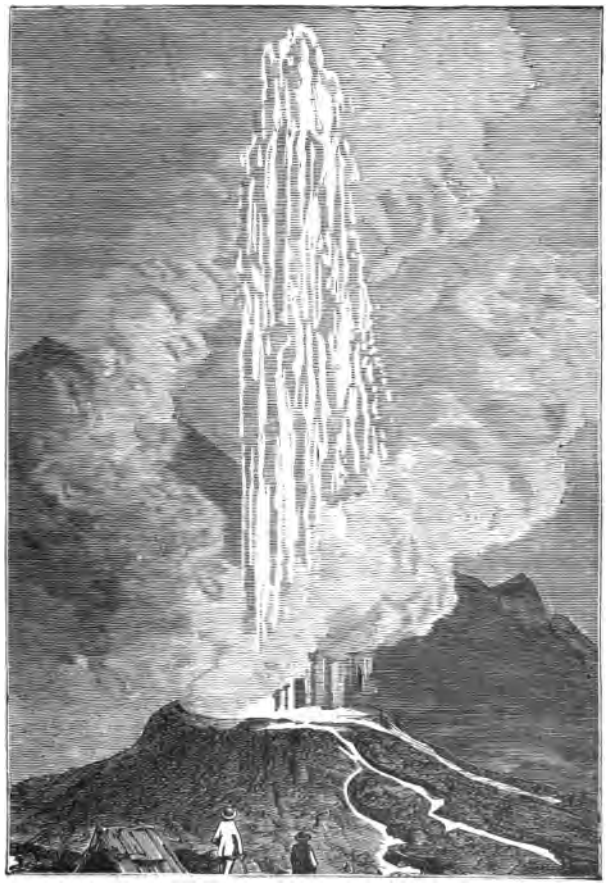


FIG. 20.—A GEYSER.

like the jet of a mighty fountain. The steam escapes in a single burst or in several; the water sinks back and lies quiet for a while, till steam is again formed, and the fountain jets again.

A toy geyser can be made of an upright tube of iron filled with water, and two gas-jets burning against the tube, one above another. Every different way that a geyser plays can be imitated on this simple little arrangement. It would take too long to explain why some geysers are too young to play and why some are too old; why some play at fixed times, and others only when a clod of earth or something of the kind is thrown into the tube; but if you could see the experiment tried on the toy geyser it would not be hard to understand.

CHAPTER VI.

THE ICE-KING AT WORK.

We have seen how water wears away the land in one place to build it up in another, how it carves channels for itself through the solid rock, and builds up new layers of rock out of the ground-up material, but we have not seen all that water can do. In its solid form, as ice, it has had a great part to perform in world-making.

I am sure you have often read of the wonderful glaciers of Switzerland, where, between the rocky sides of a mountain gorge, the ice seems like a great river flowing downward. Glaciers are found in many countries—everywhere, in fact, where the climate and the formation of the land are both favorable. We hear more of Swiss glaciers only because a larger number of people visit and write about Switzerland than about the other countries where they are to be found. Greenland and Alaska have many glaciers quite as wonderful as those of Switzerland.

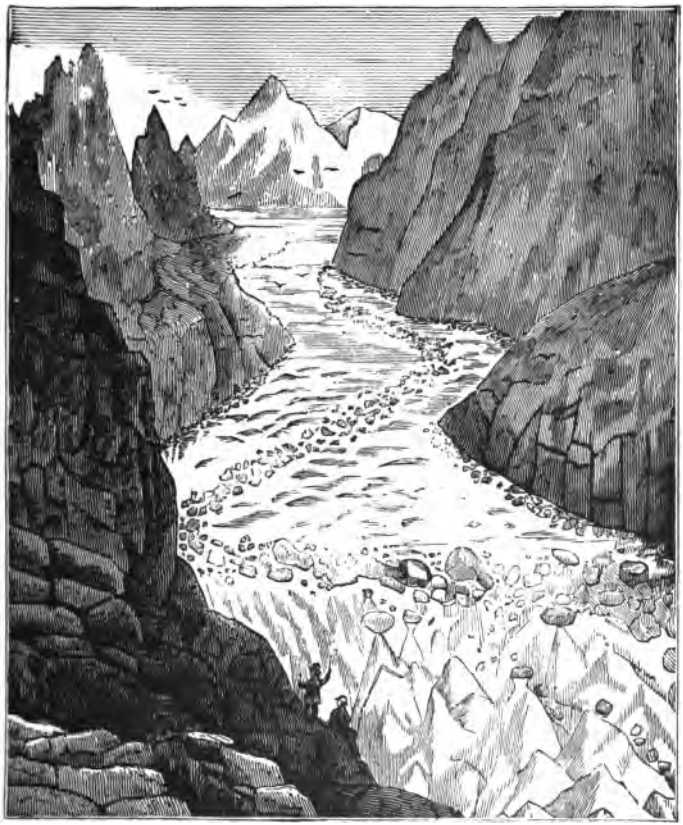


FIG. 21.—A GLACIER.

A glacier is really what it looks like—a river of ice; and more than that, it is a moving river. It does not seem possible that anything as solid and as brittle as ice could move in this way through an uneven rough channel, and fill it as a glacier does.

The beginning or source of the glacier is snow packed tightly in a high mountain valley. As we follow its course it gradually changes into a solid mass of whitish ice, scored all over with cracks and crevices, broken up into great masses and blocks of ice on the surface, and covered often with dirt and stones. Finally we come to a place where the weather is warm enough to melt the ice, and then it flows off as a stream of water.

The glaciers had been for a long time under suspicion of moving, but it was not generally believed till a man named Hugi, in 1827, built a hut upon one of them. Each year it was found that the hut was farther down the gorge.

The fact was proved, and people became interested in finding out more about this movement. A row of stakes was set up in the ice, straight across from side to side of the glacier, and two on each bank to mark the starting-point. This row of poles, as it moved, did

not remain straight; it bent like a bow in the middle, curving out towards the lower end of the glacier, showing that the middle part moved faster than the edge. This is known to be true of an ordinary river: the water rubbing against the banks and against the bottom of its bed is hindered, and moves more slowly than the water in the middle and on top does.

The glacier ice not only moves where the channel is even and smooth, but in some places where the channel narrows and is bordered by great masses of rock the wide sheet of ice squeezes itself through the narrow gorge, piling itself high in mighty blocks in obedience to the tremendous pressure behind. Of course most of this movement is in summer; the advance of the rows of stakes showed this. There are two very wonderful things to be studied out about this—the *cause* of the movement, and the way it is effected.

First for the cause: that has to be sought in the high and lonely mountain valleys. Each winter snow piles itself high on the mountain-top; each summer this snow is softened and made slushy, but not melted entirely. The soft snow sinks and packs, and is pushed down into the easiest channel. The next

winter a new weight of snow is added, making a greater pushing force.

On a cold, clear winter's day you have often picked up a handful of snow and tried to make it into a snowball, and found that it would not pack; it would crumble up in your hands. By putting a little water on it you can pack it into a hard, partly clear ball.

If moist snow is put in a mould and squeezed, a block of ice the shape of the mould can be made. Your hands cannot press the snow hard enough to make it into ice, but the mould can. Snow is nothing but ice in fine, beautiful crystals with air caught in its meshes. When you squeeze it you press out the air, and bring the ice particles near enough together for them to freeze solid. A tiny little bit of water added runs in between the particles of ice and pushes the air out before it, and so helps to make it solid; and when the water too is squeezed out, makes it freeze. Too much is worse than none at all. Each winter's weight of snow lies during the cold weather without doing much, but when the summer warmth begins to soften the snow it begins to pack, as the moist snowball does, and being a little softened, and pressed by the weight above, to push its way down through some

valley. It is hindered in its travels, and being pushed behind and hindered in front, it packs tighter and tighter till we find it, farther down in its bed, a mass of ice. The weight is getting greater and greater behind it with each winter's load of snow, and so the ice is forced down, no matter what is in the way, and the valley is finally filled with the moving river of ice.

The ice is not soft like water, or even mud; how, then, can it fit itself to the channel? That has puzzled a great many wise heads before yours. Ice is one of the brittlest things in the world, but it has a quality that we do not often have occasion to notice. It melts easily, but it also freezes easily. Faraday, one of the greatest men of science in our century, and one of the noblest and simplest men of any time, discovered this quality of ice in a very commonplace way. One hot summer's day, in a restaurant, he noticed some bits of ice floating in a dish of water. The ice was melting, and yet every time two pieces touched they froze together. Tyndall, another great scientist, has explained the movement of glaciers by this simple principle. It was he who found that ice could be crushed out of one shape into another, and that the broken bits froze at once together and made a solid

lump, as the snow does. Now, glacier ice, underneath the surface, is squeezed in a mould made of its bed and banks and the heavy weight of ice above; the moving part of the ice, which fits itself to the channel-mould, is broken and ground up into bits; but these bits, being pressed together again, freeze into the new mould that it is pushed into—that is, the new part of the channel—just as Tyndall's ice, which was first squeezed in a round mould, came out a ball, and, being squeezed again in a cup-shaped mould, came out a perfect cup of ice.

A glacier moves so slowly that it freezes to fragments of stone in its bed and on its banks, and carries them along with it (Fig. 21), scratching and scoring with them the stones it finds lower down in its channel. Where the end of the glacier melts, these bottom stones are left in a curved heap. When from change of climate the glacier ends farther up the slope than it once did, two lines of stones show where the banks were. In the picture you see a line of stones down through the middle of the glacier. These are where two glaciers have joined, and the stones mark the joined edges. These stones are always worn round by the grinding and rubbing they have received, and

are called "muttoned" rocks by the French, because at a distance they look like the round backs of a flock of sheep; they are scratched, too, in straight lines (Fig. 22).

Fig. 22.—Rock Scratched by Glacier.

From Lyell's "Elements of Geology."

These glacier signs are very important in studying what the Ice-king has done in bringing the earth to its present state. Long before there were any people to write about them, the glaciers were writing little

FIG. 23.—TRANSPORTATION OF ROCKS BY GLACIERS.

scraps of their history and travels on the stones, as the savages did, and this history we can read to-day.

Sometimes may be seen a very curious effect that the stones have upon the ice, which they protect from the melting rays of the sun. Each block of stone rests upon a pillar of ice of its own making. The stone is like the top, and the ice-pillar like the stem of a great toadstool (Fig. 23).

Icebergs, you know, are great floating mountains of ice: as not more than one-eighth of the iceberg is above water, you can guess how immense some of them are. They are really only the snouts of arctic glaciers which have pushed themselves into the sea without melting, and been broken off by the tides and the waves. When an iceberg gets afloat it sometimes comes as far south as Washington before it is broken up and melted. Usually they melt in the sea, and then rocks are deposited at the sea-bottom; but sometimes they run aground, and then on the soil of countries far to the southward arctic rocks are dropped. The icebergs and glaciers of the far past have mixed up things very much in this way.

In Greenland no rain falls—only snow; there are no rivers but ice rivers. A large part of the country

is covered by a great sheet of ice, nearly half a mile thick, slowly travelling to the sea, and there launching thousands of icebergs.

Strewed all over the northern part of our continent —over mountains, hills, valleys, and plains—is a layer of glacier stones, scratched and "muttoned," different from the rocks below them, showing that once a sheet of ice covered this country as it now covers Greenland. This broke up into separate glaciers, as we shall find out more fully after a while, filling the valleys, as the Hudson and the Susquehanna, till it came to a climate warm enough to melt the ice.

As time went our part of the earth grew warmer. We do not know why; we only know it was so. The glaciers were driven back to the arctic regions. Our country was no longer a wide, barren ice-field, but was getting slowly ready for the day when God should command it to blossom as the rose, and be a home for His children.

CHAPTER VII.

PLANTS AS BUILDERS.

Besides the forces of moving water, fire, air, and ice, which have been continually shifting and rearranging the materials on the surface of the earth, we have other builders at work. There are the plants and animals—things that have lived and had organs, and so are called organic forces; the others, because they have never lived, are called *inorganic*, or not organic.

The plants and animals helped to build up the layers of the earth, but they did so without meaning; they just lived and grew and died, dropping upon the soil, and those parts that did not soon decay — like the limbs of trees, the bones or shells of animals — were sometimes covered over and preserved in great layers. This same process is going on now.

In Virginia, near where Chesapeake Bay meets the Atlantic Ocean, lies a wonderful forest, different probably from anything you have ever seen. Tall tree-

trunks rise out of the dark water below, and stretch up and up till they are lost in the great matted bed of dark-green leaves and boughs, which seem as if they were the roof of a cavern above-ground. It is always dim and dusky beneath this roof, even at noonday.

Great coils of grape-vines bind together the tree-trunks, and out of the water rise the cypress knees—trunks that have grown up and then turned suddenly back again into the water. These serve to steady the trees and keep them firm in the wet, insecure soil. Tall reeds and grasses grow up between the trunks of the trees, and hanging masses of solemn gray moss drape their boughs. Here and there the surface of the sullen water is broken by little tussocks of grass.

The water is a dark coffee-color, but clear and sparkling, and sweet to the taste. Over all this wilderness of solemn trees and dark water reigns a death-like stillness, broken only by the humming of millions of mosquitoes or the splash and rush through the water of some water-snake or venomous moccasin which has been sunning itself on a log, and drops into the water on your approach. Here in this Dismal Swamp the battle between land and water is going on. The land, aided by the plants, is continually gaining ground.

FIG. 24.—A TROPICAL MORASS.

Into the water the leaves are always falling, the dead boughs from the trees, the dripping gray moss and the juniper berries, making a solid mass and slowly filling up the pools.

The water has the power of keeping the leaves from decaying as they would on land. This water is a very wonderful thing. Many years ago, when I was a child, I went out from Norfolk, Virginia, to see the old war-ship *Pennsylvania*, that was lying near the city. One of the ship's officers handed me a glass of what I took to be brown sherry wine. I tasted it, and found it was pure, sweet water. This was the coffee-colored water of the great Dismal Swamp, and it will keep sweet for twenty years on account of the juniper berries that have colored it. I think the glass I drank had been something like that time in the hold of the ship.

In some of the Louisiana swamps the surface of the water is covered for many thousands of acres with a growth of grass and plants, making what is called a floating prairie, where twenty years ago there was an expanse of clear water. The grass grows thicker and thicker every year. Sometimes, when this floating prairie gets heavy and water-soaked, it will all sink

into the shallow water beneath. When this has happened often enough, the lake of the past will have been converted into a soggy swamp. Willow-trees seem to come up of themselves, and their roots bind more firmly together the slight soil and grass roots, and the land is born out of the water, gaining solidity and firmness year by year. These floating prairies, when the grass and roots and earth are only two feet thick, are strong enough to allow a man to walk about with ease, though they are floating on clear water several feet deep underneath.

In some countries — Ireland, for instance, where there is a great deal of rain—moss and small plants growing on a soft, muddy place make a deep coating. Each year's growth is packed closely down on the growth of the year before. In this way a peat-bog is formed. In the open air, when plants perish, they dry up and blow away, or decay, and so are lost; but in the peat-bogs the water, like that of the Dismal Swamp, preserves things that drop into it. Bog oak, out of which ornaments are sometimes made, is oak that has been preserved in the water and turned black and hard with years, but is perfectly sound.

About a hundred years ago the body of a woman

was found deep down in an Irish peat-bog almost perfectly preserved; even the hair and skin and nails were sound. She must have been there a long, long while, for on her feet were, not shoes, but ancient sandals, such as have not been worn for hundreds of years.

The solid packings of moss forming peat are cut into squares and dried, and then used to burn instead of wood or coal in many parts of Ireland. This peat is coal partly formed. When it is pressed very, very hard by machinery it is made into a kind of coal which burns quite well. Some of the peat-bogs in Europe were formed by the cutting down of the forests by the Romans. The trees were left lying where they fell, and often dammed up springs, and so a bog was formed which in the eighteen hundred years since has grown into a peat-bog.

In most bogs formed in this way the peat is not pure; it is mixed with mud and sand; but in some places, as in the swamps along the Mississippi, the water has been strained of its mud before it reaches the swamp, so the peat is made just of layers and layers of leaves packed together by the water, and is perfectly pure.

Sometimes, when solid continents or islands have sunk beneath the water, whole forests have gone down with them, the fallen trunks of trees and stumps in place; the dirt has sifted over these, till new land has formed above the old, new forests have grown up and fallen and been buried. A cut through such a bed may be seen in Figure 26; the layers of sand and shells between the layers of tree-trunks show that it has been under water between-times.

In New Jersey there are great buried forests of cedar which have lain there for centuries uninjured. People actually mine for timber. Some of the tree-trunks lie fifteen feet underground. One of these trunks, which had lived for five hundred years, as showed by the yearly rings, was underneath another which had a thousand yearly rings.

In Louisiana, where the timber grows heavily, great trees are often torn up and carried down-stream by sudden and heavy floods. These get wedged, and dam the stream, so that though the water can filter through, everything which comes floating down the stream is stopped and packed together, and forms great natural rafts. About forty years ago the Government had one of these removed, which measured ten miles long,

Fig. 25 —Mining for Cedar Logs in New Jersey

seven hundred feet thick, and eight feet high. It was covered with plants, and even a few great trees sixty feet high were growing on the top.

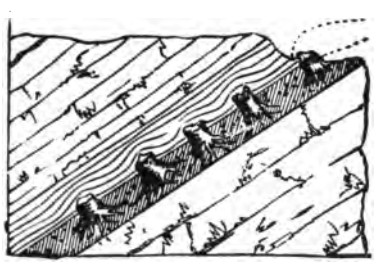


Fig. 26.—Section of Cliff.
From Lyell's "Elements of Geology."

The plants we have been talking about are good-sized—some of them large trees; but there are other earth-builders among plants too small for the eye to see. These are very wonderful little plants; in many ways they seem more like animals than plants. Each one is a little greenish dot of jelly, with a glassy coat like a shell. They may be found in almost any water, but it takes a good magnifying-glass to see them. I have found them in the water from a running stream, in a spoonful dipped up from the hollow made in a

country road by a horse's hoof, or in a way-side pool. In the seas and lakes and rivers of the Old World these little creatures lived and multiplied and died, dropping to the bottom, and making earth of their tiny glassy shells. A piece of this earth smaller than an ordinary bullet or green pea would have in it over two hundred million shells, and yet this earth covers thousands of acres several feet thick.

Out in the western part of Virginia, only about a hundred feet below the top of one of the highest mountains in the State, there is a lake nearly a mile long and a quarter of a mile broad. It is as clear as crystal, and if you take a boat and go out upon its still surface you will probably look at the sky or the green banks till some one says to you, "Look down." Then you see a wonderful thing. Down at the bottom of the water is a dead forest; the trees are standing up, with their naked branches spreading abroad in the water far below you. How such a lake can exist so high up it is difficult to guess. The water must come from the small portion of the mountain above it. Some years ago an old man said that he remembered, about seventy years before, when there was no lake, only a valley filled with trees. How or why the lake

came no one seems to have found out, though many guesses have been made. It is thought that the water which drained from the mountain used to escape, but that the way of escape was somehow closed, and so the water filled up the valley. The trees, of course, died, but the water kept them from decaying and being lost. I do not know of any other place in the world just like this; but the same thing may have happened long ages ago, and trees in this way have helped to be earth-builders.

CHAPTER VIII.

THE BUILDERS UNDER THE SEA.

The Pacific and Atlantic oceans, where the water is not too cold, are dotted over with myriads of islands of a very peculiar kind. Many of these islands can be found upon the map, but a great multitude of them are too small to be put down.

These are coral islands, and they are formed, little by little, by tiny living beings, some of them so small that you can only see them plainly by using a magnifying-glass. The Florida Keys, the Bermudas, and other islands near our Southern coasts are the work of the coral animal, as well as the reefs along the Florida coasts. Many of the islands built up in this way are ring-shaped—round, or oval, or irregular—but enclosing a quiet lake. In some the ring is incomplete, and the water inside it is a landlocked bay; in others there is a row of islands which, if connected, would make a ring. The Bermuda Islands are such a row.

These curious islands are called atolls. The land lies low, and the curved strip of land forming the island bears a grove of feathery palms and beautiful flowering trees, bordered by a beach of pure white sand. Seen from above, an atoll would look like a gigantic green wreath floating on the bosom of the water (Fig. 27).

It must be a wonderful thing to be the first person

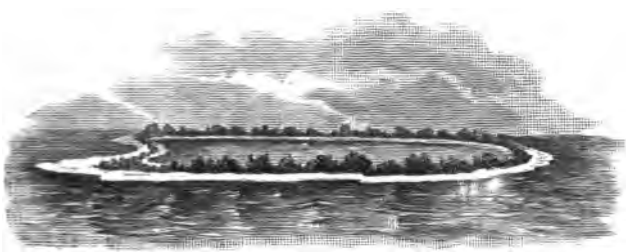


Fig. 27.—ATOLL.

who has visited one of the lovely, lonely atolls of the Pacific, whose only inhabitants are birds. Fifty years ago this was a more common occurrence than it is now, when the seas are so full of great ships and steamers, as well as smaller craft, that most of them have been at some time visited. Professor Dana, who went out on an exploring expedition some time ago,

says that "on one atoll, where no natives ever dwell, the birds were so innocent of fear that we took them from trees as we would fruit, and many a songster lost a tail feather as it sat perched upon a branch apparently unconscious that the world contained an enemy. They had never found out the vow of eternal enmity sworn against the birds by the boys. Poor little heathen birds! How they did need a missionary!"

You may have heard of the coral insect, and of its wonderful industry in building up great islands in the sea, as if coral was built as honey-comb is. The coral animal is not an insect, nor anything like one, and it builds the coral precisely as you build up the bones in your body. It is a sort of flower-animal, shaped like an aster or an anemone or a daisy. It has nothing of the flower about it except a resemblance in shape, but is as much of an animal as an oyster or a fish. The coral polyp has a thick stem crowned by a row of petal-like arms arranged about a centre, or sometimes several rows so arranged. The stem is the body, and in the upper part of this is a hollow sac—the stomach. The centre of the flower is the mouth, and the petals are feeders to catch and draw in the floating food that comes within reach. Some of the sea-anemones do

not make coral, and others do, but all are constructed on this simple flower plan (Fig. 28, *a*, *b*).

When you eat and digest your food, new particles of flesh are formed. These are pushed in between the particles already there, and at the same time old particles which are dead and of no further use to you are cast off. While you are growing, more new particles are made than old ones are cast off. When you are grown, those that are taken on are equal to those that are cast off. This constant change goes on in the bones as well as in the flesh, though more slowly.

Fig. 28.—Coral with Polyps.

Such a change is all the while taking place in the coral polyps. The coral is the skeleton of the polyp. Instead of the skeleton being all inside the polyp's body, as yours is in you (except your teeth), or all outside, as it is in the oyster, it is partly in and partly out. In the lower part of the stem of the coral ani-

mal, below the stomach, is the skeleton; as the polyp grows it keeps adding particles to its skeleton, and as it casts off less than it adds, the skeleton grows too long for the polyp, and is left behind as a solid stem, on the tip of which is the flower-like animal (Fig. 28, *a*).

The polyp, though an animal, is of a very low order. It is really only a stomach, a mouth, and feeders. Although it has no eyes, it can somehow tell when its prey is near, for it is quick to reach out its beautiful petal-like arms and draw it in. It has no ears, but the softest footfall will cause it to draw in all its petals and shrink down into a little brown knob which can scarcely be found among the sea-weed at its foot (Fig. 28, *b*). It cannot move about, for it is fastened tight to its coral stem, but it is provided with a wonderful contrivance for the capture of the prey beyond the reach of its arms. All along the beautiful petals are thousands and thousands of tiny pockets, and in each one is coiled up a long, slender thread. Let an unwary little fish come within range, and in a second hundreds of these threads are shot out, each turning itself inside out as it comes. The threads are barbed and poisoned, and woe to the fish who is lassoed. He

is stunned, and soon dies. Then the victim is drawn into the innocent-looking flower. After the meal is digested, the flower turns itself wrong side outward, and so gets rid of any fish bones it cannot digest. Out of food so caught and digested the solid coral is formed. A single polyp would form only a small stem, but the polyps increase by sprouting from buds, or by one of them stretching and splitting up into two or three or a dozen polyps, till great branches or sheets of them are formed with the coral underneath. The shape of the clumps or branches is determined by the way they increase (Figs. 29 and 30).

Fig. 29.—CORALS.

From Lyell's "Elements of Geology."

Reef-making polyps cannot live in the depths of the sea, but when they lodge near enough to the surface, and in water which all the year round is never cold enough to kill them, they grow steadily, though slowly, and increase enormously in numbers.

All through the Pacific Ocean these curious islands are found. They are of three kinds; either an ordi-

nary island, surrounded by a pure white beach made of coral sand, or an island with a ring around it, or one which is nothing but a ring. Sometimes the beach or ring is broken up—that is, some parts of it do not rise above the surface of the water, and the

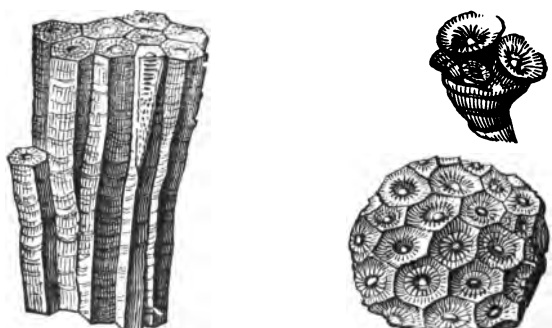


Fig. 30.—CORALS.

From Lyell's "Elements of Geology."

ring is only marked by dots of islands arranged around in a circle.

Wherever such islands occur they have been slowly built up by coral polyps. When the clumps of coral have grown up to the surface, the branches are broken off by the waves and ground into powder or coral

sand, as it is called if coarse, and coral mud if finely ground. This powdered coral sinks over the spreading branches of the living coral and finally fills them up, and with shells and bones they heap up above the surface of the water and gradually harden into rock.

Below the water, on the sloping beach that runs out towards the sea for a little distance, you may see, if you look downward, a wonderful fairy garden. The polyps sometimes look like beautiful animal flowers, waving their fringe of feelers like leaves with every movement of the water; other fan-like corals, called gorgonias, send the pink lace-work of their leaves up through the water, while bright fish dart in and out amid the curious animal forest, showing their vivid colors against the white background of the coral sand.

Many of the polyps are too small to be seen without a magnifying-glass, so you would only see the clumps and trees of growing coral covered over with a coating of a soft, fleshy substance if you looked at them through the water.

The peninsula of Florida, on the south-eastern end of the United States, is a land made by the coral polyps. Several reefs have been built, one beyond the other, and the space between became gradually

filled up with drifting sand and floating wood, till the solid land was formed. There are still reefs beyond the main-land called the Florida Keys.

Just why reefs should form as they do in lines and rings off the shore of the land, or make ring-shaped islands in mid-ocean, is not absolutely certain. Years ago, when Mr. Darwin was a young and unknown man, he gave the first explanation that seemed really to satisfy men of science. For forty-five years these ideas of Darwin were believed in by all the world, but of late years there has been much talk and much study about the question, and geologists are divided. All hold the same *facts*—it is the reasons for them that they cannot agree upon. So it seems to me wiser to give you the facts only, and not attempt to give an explanation that may not prove true.

In great storms near the coral islands, the water often looks milky, whitened by the fine coral mud.

In shallow seas corals often grow up in a sort of umbrella or mushroom shape, with a central stalk and a wide, flat top. A great many of these will unite and make an island, held up by great columns below. Sometimes in the Pacific a ship has run aground on one of these umbrella-shaped reefs, the column has

broken, and, to the surprise of the crew, the vessel has gone safely ahead.

Fig. 31.—MAGNESIAN LIMESTONE.
From Lyell's "Elements of Geology."

There are many other kinds of sea creatures which are helping to build up land in the bed of the ocean. Fish, large and small, when they die, drop their beautiful shells, or their skeletons, and these collect in the sea depths, and after a while become packed into a solid stone. In this piece of limestone (Fig. 31), see how closely the shells lie together; in other pieces there will be dozens of different kinds packed in the broken bits and dust made by thousands of other shells (Fig. 32).

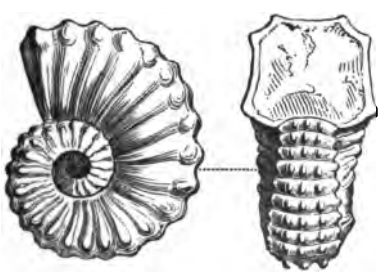


Fig. 32.—FOSSILS OF CHALK.
From Lyell's "Elements of Geology."

The chalk cliffs of Dover, which gave to England her poetic name of Albion (from *albus*, white), are solid masses of tiny shells.

At the bottom of the Atlantic there are to-day forming just such beds of chalk, not yet made into a solid mass, but on their way to be (Fig. 33), and if the chalk which was made ages ago and that which is making to-day are compared, they will be found to be very much the same.

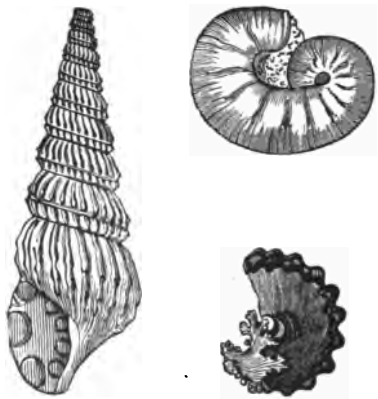


Fig. 33.—Fossils of Chalk.

From Lyell's "Elements of Geology."

CHAPTER IX.

THE CRUST OF THE EARTH.

The earth, as you know, is a great globe, eight thousand miles through from side to side. Geology would not be a possible study if we were obliged to learn about the earth, down to its centre, four thousand miles below the surface. All this mighty mass, except a sort of skin which encloses it, as the rind encloses an orange, is made up of metals and minerals, just as the fire has moulded them. At first the "rind" was only the outer part of the globe of melted rock, which had hardened as the earth cooled down.

You remember what it was that changed the hardened surface of the globe into the wonderful layered crust that now covers it: how the air and water and fire went to work, the air and water powdering the rock and letting it settle into the water's depths; and then, when this had again become solid, how the imprisoned fire burst through, turning and tearing and wrinkling the layers.

The crust of the earth, so far as we know, is not more than ten miles deep anywhere, and in many places is not more than three. This seems a wonderful depth when we think how long it would take to walk so far, but it is very little when compared with the size of the earth.

Of course we could never have reached to the bottom layers if they had all settled quietly down, one on top of the other, and stayed just where they first settled, for the deepest mines cut down through only about one mile; but fire has come to our help, and broken and tilted them up so that the edges of the layers are exposed, and can be studied better than if men had dug down to them.

The crust of the earth is like a wonderful book, with its leaf upon leaf, close shut, yet each bearing upon it the record of a life long passed away. For hundreds, even for thousands, of years the pages of this book lay unread. Men had seen them; they had perhaps guessed and wondered at the curious forms impressed upon them; but no one had looked at them with a seeing eye, no one had worked out the problem, no one had guessed the riddle of the rocks. Underneath these written pages, where the history of the

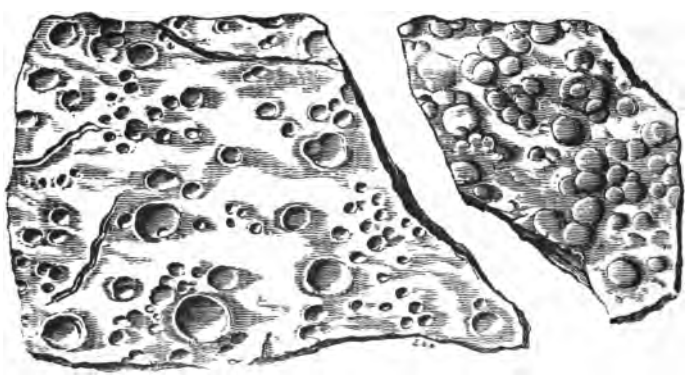
past may be read, lies the fire-made rock, like so many blank pages. No life had ever existed there, and so the pages are empty.

The crust of the earth is very irregular; great mountains and plains rise above the level of the oceans, and mighty valleys sink beneath their depths. The highest mountains stand only about five miles above the sea-level, and the deepest ocean valley sinks only about the same distance beneath its waters. Great as this unevenness of the surface seems, it is less, in proportion to the size of the globe, than the roughness of its rind is to an orange.

When you look on the map of the world, the continents appear to be very irregular in shape. There seems to be no sort of rule in their formation; but there is: some things are alike in them all. Each continent—Europe and Asia being one—is surrounded, or nearly surrounded, by water; the mountains run somewhere not far from the rim, making of each a great shallow, irregular basin, and the highest range of mountains is nearest the largest ocean. In North America, for example, the Pacific Ocean is larger than the Atlantic; the Rocky Mountains, which face the Pacific, are higher than the Eastern ranges that face

the Atlantic. The same thing is true of the other continents.

During the struggle of the imprisoned giant, Fire, to make his escape, many changes have taken place in the shape of the land, but the changes have been a



Figs. 34, 35.—Rain-drops and Worm-tracks on Green Shale.

From Lyell's "Elements of Geology."

sort of growth or development; the continents have gradually become larger, the land has slowly been lifted up out of the water.

Layered rocks are of as many kinds as there are of sea-shores and lake-bottoms. Some of them are fine

mud, some sand, some pebbles, and some broken bits of stone or coral cemented together and hardened into rock. A layer has often been traced from its condition as mud or sand to the place where it is a layer of solid rock, with all the different stages of change between.

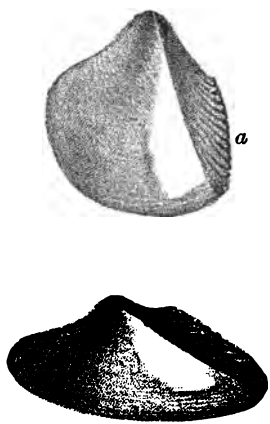


Fig. 36.—A Distorted Shell.

In the layered rock sea-shells lie just as they lie in the water's bottom. You remember how Hugh Miller saw, on the slab of sandstone his hammer laid open, ripple marks such as he had often seen in the sands of Cromarty Frith, and he knew he had come upon an ancient sea-beach.

Think how strange it must seem to lift one layer of rock from another and find there the impression of rain-drops—the record of a rain-storm that had swept over some lonely sea-shore millions of years ago, which yet is as clearly to be read as if the drops had fallen yesterday (Figs. 34, 35).

Earth, or sand, has been changed into solid rock in

several ways; sometimes it has been slowly baked by the inner fires, somewhat as clay is baked into brick in a kiln. At other times it has been pressed into stone by the enormous weight of the layers on top of it. Shells are found in rock which has been made in this way pressed into curious shapes (see Fig. 36). The upper one of these shells (*a*) has its natural shape; the lower is the form into which it was pressed by the weight above.

Fig. 37.—Sea-worm on Oyster-shell.
From Lyell's "Elements of Geology."

In Figure 37 you see a shell on the inside of which some curious worm-like cases are glued. The dead oyster-shell must have lain long enough on the bottom of the sea for the sea-worm to have built its case, which it takes some time to

do, before the earth settled over and enclosed them both.

It is very easy to see that when one layer of earth settles over another the rock would easily split in that direction; but rocks split in other directions too (Fig. 38). You see there are three different sets of lines in these rocks, and the rock will split along either of these. A and B are the layers formed by settling;

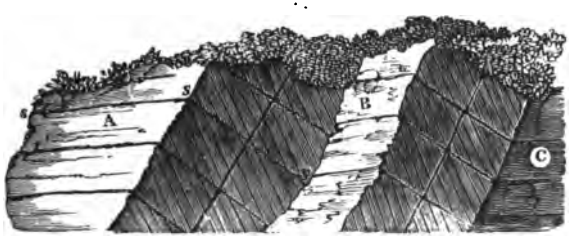


Fig. 38.—Stratification, Joints, and Cleavage.
From Lyell's "Elements of Geology."

C is one of the cracks made by the shrinking of the rock as it cooled; but the other lines, diagonal to these, are formed by heavy pressure. If you take such a thing as beeswax or white-lead and put it under heavy pressure, it will come out in such a condition that you can easily separate it into sheets.

Slate that is used for the roofs of houses is stone which has been put under such heavy pressure, while it was hardening, that it came out as beeswax or white-lead would, and will split into thin sheets. The pressed and distorted shells in Figure 36 are frequently found in rock like this, and the shells are always pressed out of shape in the same direction as the cleavage of the slate, no matter in what position they had fallen, showing that there was no accidental distortion in the form of the shell.

CHAPTER X.

MOUNTAIN-BUILDING.

THE most beautiful scenery on the face of our earth owes its beauty in great part to the presence of mountains. Whatever may be said for the beauty of ocean scenery by its lovers, it is still true that the mountains divide the honors with the sea.

Mountains have been formed in different ways, and are different in their appearance, but each possesses a beauty of its own. The soft-swelling, forest-crowned domes of the Blue Ridge and Alleghanies, in the East, are scarcely less beautiful than the majestic snow-crowned peaks of the Rockies, in the West.

The real mountain-builders of the world are the earth-builders, fire and water; and the different ways in which the work was done came from the various combinations of these forces. After the water had done its work in depositing the layers, one on top of the other, under the sea, a change would come—the

hardened crust would be slowly wrinkled up by the shrinkage of the globe beneath. This shrinking was in part due to the cooling of the melted portion in the interior, and part probably to the escape of gases and water in the form of vapor. The skin, or crust, that would fit smoothly over the larger globe would naturally wrinkle over the globe that had become smaller.

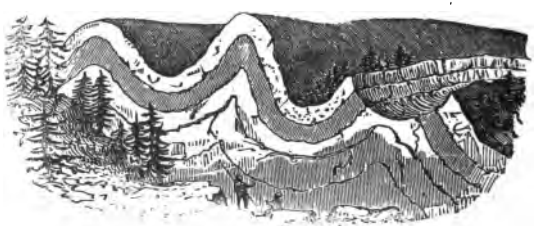


Fig. 39.—Section illustrating the Structure of the Swiss Jura. From Lyell's "Elements of Geology."

Such wrinkles are our mountain chains as they first appeared. Some mountains are still little more than such wrinkles, with the layers unchanged (Fig. 39). In the picture we see just how the layers follow the curves of the mountain. A great cleft has been made through the three wrinkles, or mountain ranges, and this enables one to see just how the layers run in the

two left-hand peaks. In the right-hand range water has come in and cut through, and lowered the mountain-top. Fire is the cause of mountain-building, either directly or indirectly; while water carves and sculptures and wears away in various ways the simple folds or wrinkles as first made.

First we will try to understand just how the crust of the earth is thrown into wrinkles. Take a dozen pieces of cloth or flannel, cut them the same shape and

Fig. 40.—Wrinkled Layers.

size, and lay them on the table in an even pile, put two books at the ends, as you see in the picture (Fig. 40), and one on top to hold them in place; now press the two standing books gently towards each other, and the cloth will wrinkle up, the layers still lying on top of each other, or *conformably*, as it is called. An experi-

ment has been made with layers of moist clay, put one above the other in a pile, a weight placed on top, and then pressed as the flannel is, gently together. When the open sides are watched the layers of clay are seen to wrinkle up, just as they did ages ago in the formation of mountain chains; where the pressure is great, many wrinkles are formed side by side, with valleys between, as in the case of the Rockies and Cordilleras and our Eastern mountains.

The Alleghanies and Blue Ridge, as well as the White and Green mountains of our Eastern States, have been made by such a crumpling of the earth's crust, followed by the action of water and ice. The rains have washed and worn away the crumbled rock; the air and the ice have helped to do the work, till the original forms of these mountains have all been changed.

One of the most singular mountains in the world has been made entirely by the action of water (Fig. 41). The layers of rock running across the mountain look as if they had been built by a stone-mason, and the little cones of washed earth as though they had been sculptured out of the rock by tools. These *have* been built and sculptured too, but they

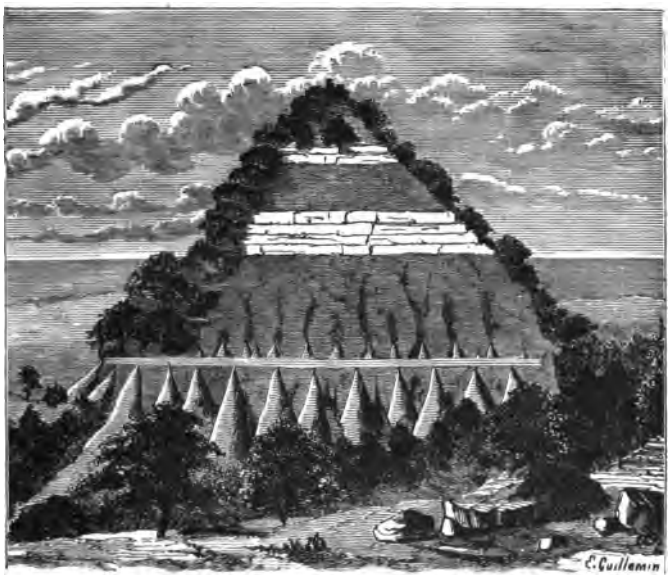


Fig. 41.—Pyramid Mountain.

From Reclus's "Earth."

have been done by water, and not by the hand of man.

From the kind of layers forming mountain ranges and the shells and bones found in them, it is known that the part of the earth's crust which was forced up into wrinkles, as the inner portions of the globe con-

tracted, lay along the sea-bottoms, but near the coasts. There were reasons why the earth's crust here was softer than elsewhere, and it gave way along its weakest lines.

Of course this solid crust has cracked and broken under the strain. In some places these cracks have been widened by water flowing through them, and as a result we have the deep clefts in the rocks, with streams running through the bottom of them that are called cañons (pronounced *canyons*) (Fig. 42). No picture can give an idea of these wonderful walls of rock rising up on each side of the stream running along at the bottom, sometimes thousands of feet high.

Where the crust of the earth is cracked through by the action of fire, one half will sometimes settle lower than the other, and then the crack will close up. Of course, where this is the case the layers will no longer match. This is called a *fault* by miners, who are very much troubled when they are engaged in digging out a layer of coal or iron, and suddenly find it end in a blank wall of rock. They know that this is a fault, and that the layer they want to follow is either above or below them. A knowledge of geology is a great help in determining which way they shall work

Fig. 42.—A Cañon.

in trying to find the layer, or vein, they have lost by the fault.

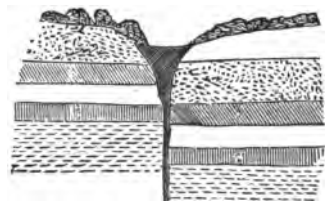


Fig. 43.—FAULTS.
From Hooker's "Mineralogy and Geology."

The causes that are changing the earth's surface to-day, as you know, are the very same that were at work changing it in the past; but we must remember that there is a difference between the past and the present. The earth's crust was thinner then, and the forces struggling under it were stronger; so we should expect some difference in the results.

There are places on the face of the earth where the rocks gave way, and the melted stone has broken through the weakest spots, and flows out as lava. These are volcanoes. In the past it seems probable that the fire and lava, gases and steam, poured out not only in spots, but along lines; that there were long cracks and fissures through which the interior fires escaped. In the far West there are vast tracts of land covered with sheets of lava nearly half a mile thick, which it seems impossible the few extinct volcanoes there could have poured out. The Cascade and Sierra

ranges seem to be built up by the outpouring of lava along their lines.

This country was the scene of a terrible eruption; but now there is not a single active volcano left. The hot springs and geysers are all that is left to bear witness to the almost exhausted force of the fire that once did such a mighty work there in mountain-building.

CHAPTER XI.

METALS AT HOME.

THE crust of the earth is made up of many other things besides layered stone, and very valuable things they are, too. Gold and silver, iron and copper, lead and tin, as well as many other metals, are found among the rocks.

Iron is really the most valuable of the metals. We are accustomed to think that gold is more valuable because it will bring a higher price. But think for yourself, and you will see what thousands of useful things are made of iron and steel, and how very few real uses, apart from money, gold has. Nothing else is so good for filling teeth, a mixture of gold is used in some kinds of photography, and gold is valuable for coins because it does not rust or corrupt; but its real uses are not many.

If you were cast away on a desert island, which would you choose to find, a bag of gold or a case of

tools? One single knife would outweigh in value all the gold you could carry. Comparing the two metals in such a way as this makes us see how much more really valuable iron is than gold. Savages of all countries have made their first metal tools of copper, or a mixture of copper and other metals, called bronze. This is because copper is found in a purer state than iron, and is softer, so that it is more easily obtained, and more readily worked with the simple tools that savages use. So you, in your desert island, if not a savage, at least living the life of a savage, might prefer the softer metal, because you probably would not have the means of separating from its ore the harder metal, or of working it. In reading about savage people you often hear of gold and silver and copper, but never of iron, and this is the reason.

Gold and platinum are always pure, copper and silver sometimes so, but are also sometimes found in the condition of ore. *Ore*, correctly speaking, is a mixture of one or more metals with earth or other mineral matter. This is not a common mixture, such as you could make by stirring salt and sugar together, but is a union of another kind, a *chemical* union, by which two things may be so united as to form a new

Fig. 44.—Scene at an Iron Mine.

substance unlike either of the two out of which it has been made. Air is a *mixture* of several gases; water is several gases in chemical union. Air remains a gas, but water is utterly unlike a gas—it is a liquid.

You often hear of gold ore, but it is not truly an *ore;* the pure gold is mixed with other minerals or metals. Iron ore is a chemical union of iron and other things—one of the gases of the air and water, for example. Iron ore of a common kind is iron rust; the solid, heavy, black metal has been turned into red, powdery dust.

If you have travelled much you have probably noticed how very red in some places the earth is; the mountain land in Virginia and many parts of New Jersey, for instance, is like this. I have seen the ground in Virginia look fairly crimson in the sunlight. This red look of the earth means iron, and iron well rusted at that.

Underneath bogs and swamps great flat cakes of iron ore are found, sometimes as large as the swamp, and one or two feet thick. This collects in a very curious way. The rusted iron, which is scattered all through the earth, will not dissolve in pure water; but when matter that has once been living, either vegeta-

ble or animal, decays, it changes the water that flows through it on its way down through the crust of the earth, so that the iron rust dissolves in it. This is carried down till it reaches some layer of earth or rock which the water cannot get through. There it settles, and in the course of years a great flat bed of iron ore is formed.

Iron is often to be found somewhere near these great beds of decaying vegetable matter; it is generally found very near the coal-fields, and these were once great forests. Time and heat and pressure have changed them from wood into coal.

A great deal of labor is required to dig the iron ore; mighty derricks lift it, vast furnaces, white hot, are waiting to smelt it, and so separate the iron from the useless matter in the ores. Life near an iron-mine is very curious and interesting.

In Cornwall, at the south-western point of England, are to-day the same mines that were worked before the birth of Christ. The Phœnicians, who were the seafaring men of those days, used to come to England —Albion they called it, because of the white chalk cliffs along the southern coast—to get the copper and tin from these mines. Some of them have been dug

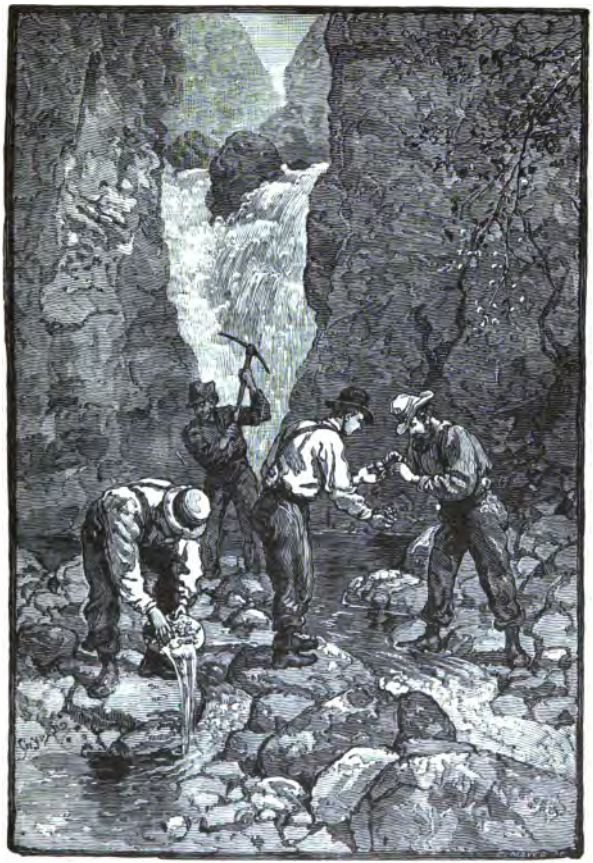


Fig. 45.—Placer Mining

down and out so that they run under the bed of the sea, and when there is a storm the miners can hear the great waves hurling themselves on the rocks and breaking in thunder above their heads.

In these Cornwall mines are found tin and copper in some places, and iron and lead in others. A very curious thing has been discovered about them: all the tin and copper mines run east and west, while all the lead and iron run north and south.

The layered crust of the earth, as we know, has been many times upheaved and heated and cracked by the fires beneath. Sometimes the melted stone ran up and filled these cracks, and hardened there, as the basalt did making Fingal's Cave and other wonderful formations; sometimes, as we have seen, the cracks closed after one side had slipped and sunk down, so that the layers on one side did not match those on the other. The rocks have been broken and healed again till they are all seamed and scarred. Many of the cracks were not filled at once with melted stone, and did not close. These were gradually filled later. The hot waters of that ancient world, full of dissolved metals and minerals, dripped and oozed through the cracks, leaving behind part of the

material which they had dissolved, till each crack was filled. These are called veins, and are filled sometimes with gold, sometimes with silver or other metals, and sometimes with minerals. The beautiful striping of agate, for instance, comes from such a cause. All metal veins are supposed to have been formed in this way.

The quantity of gold in circulation was not very great till about forty years ago, when gold was found in many places nearly at the same time. Our Western country and Australia were both settled in a wonderfully short time, because of the rush to the gold and silver fields after the precious metals had been discovered there.

Mining for gold is in some respects very peculiar and interesting. The metal being pure, it lies embedded in a clear whitish stone called quartz. You have probably seen Indian arrow-heads which have been chipped out of this stone, and know its look. Gold is found with other metals and minerals, but it oftenest occurs in quartz. The falling of rocks, the rattling about in the mountain torrents of broken bits of gold-bearing quartz, have turned the stone fragments into pebbles, and set the gold grains free.

Fig. 46.—Hydraulic Mining.

The first of the Western miners used to shake this gravel in pans, and the gold grains, being heavier, would sink and be afterwards collected. The common slang expression, to "pan out well," came from this method of collecting gold. This was called placer mining. Then the cradle, with water running through it, was used as an improvement upon the earlier method. This also soon proved too slow for our American haste to get rich.

Change after change was introduced, each as an improvement upon the last, till a new method, called hydraulic mining, was adopted in the end. It is called hydraulic from *hydra*, water, because water does the greatest part of the work.

To understand just how it is done we must get a clearer idea of the state in which gold is usually found. There are some gold-mines where the gold is shut up in the solid quartz, and has to be dug for and taken out of the solid rock as the kernel is taken out of the nutshell. But most of the gold in the world is in among the broken fragments of rock and pebble banks which fill the beds of old rivers now dry. By the old mining methods these were painfully dug out, washed, and the gold collected.

Now the water digs the ore, washes it, and separates it. A great engine, looking like a cannon more than anything else, shoots an immense stream of water against the gravel-bank, wearing it away, bringing down great quantities of stone and pebbles, with the gold in grains and threads among it. The stream is so strong that enormous rocks weighing thousands of pounds are tossed in the air as though they were pieces of wood, and an avalanche of stones is carried in the water as it rushes down the slope. The heavier gold grains drop as the mass moves on.

In one way this kind of mining has proved a great curse to the country. In more than one place whole river-beds have been so choked with the rocks and earth that when the water rises in spring terrible floods come, and the whole country is covered with the powdered stone, the crops are killed, and the soil very much injured; towns are almost ruined, and farm buildings totally destroyed. The greatest efforts have been made to put a stop to hydraulic mining by law, and there is no telling where the fight will end, and who will be the victors in the contest.

CHAPTER XII.

A STUDY OF BONES.

I HAVE been trying to take you with me, while we looked into all the forces and agencies that have been building up the earth and bringing it to the condition which we now know. This is one kind of geology—it is called *structural*, because we are by it learning about the structure, the *building*, of the earth. Now, I want you to begin in another way, and we will follow the different forms of life in the vegetable and animal world as they followed one another, beginning with the simplest creatures—such mere lumps of jelly that it is hard to tell whether they belong to the animal or vegetable kingdom. Such a study as this of the life of the past is called historical geology.

Long before the science of the earth was thought of, a careful study had been made of living animals and plants. To do this properly, and make it easy to

remember, they were arranged in different classes. Everything in the world is in this way divided into three kingdoms—animal, vegetable, and mineral. Take one of these kingdoms—the animal, for instance, to make the divisions clear—and we find it divided into four grand divisions. The lowest of these is the Radiates; that is, creatures that have no backbone, but which are formed by rays going out from a centre, like star-fish and coral polyps. (2) The Mollusks, or shell-fish, like oysters and clams. (3) Articulates, insects; and (4) Vertebrates, things with backbones. Under these divisions come what are called classes. Under the backboned animals are four classes: fishes, reptiles, birds, and mammals. Under the classes are orders; under the orders, families; under the families, genera; under the genera, species; under the species, varieties. To make it simpler, and to have something to look back to if you are in doubt, I will write these in a list just in the order in which they come. By the side of these divisions I classify you to give you a notion what it means. I do not know your name nor where you live, but I shall just imagine that your name is John Smith, that you live in New York, and belong to the white race.

John Smith belongs to:

1. Kingdoms.....Animal kingdom.
2. Divisions.....Mammal division.
3. Classes.....Human class.
4. Orders.....Caucasian, or white, order.
5. Families.....American family.
6. Genera.....New York genera.
7. Species.....Smith species.
8. Varieties.....John variety.

Of course this is not correct, but it is near enough the truth to make it easy to understand what is meant by classifying an animal or plant.

This arrangement into these divisions is not merely made for use—though it *is* very useful—it is rather a finding out of a truth than the invention of a system.

When geology began to be studied, it was gradually found out that beings had come into existence—that they were found in the rocks—in almost the same order in which scientific men had already arranged them. Science is not the making up of a system, it is the discovery of something that already existed.

George Cuvier, a Frenchman who lived and labored about one hundred years ago, made a general study of bones. He found that between the different bones

in animals' bodies there is a curious relation; so that when one bone, say a tooth, is different from the usual form, you may expect to find the foot different too. We do not understand the reason why this should be so; we only find that it *is* so as a matter of fact. When such facts as these are found to exist always, they are written out in a short and general form and are called natural laws.

By studying the great number of skeletons of animals which still exist, Cuvier was able to find out what parts changed together; that is, he found out the rule which God had made for himself in creating life. After long years of such study, Cuvier could tell just what animal a bone belonged to when he saw it. This knowledge was a wonderful help to him when he began to study the bones of unfamiliar animals—the bones dug out of the rocks. He did not have all the bones of any one kind of animal to fit together like the pieces of a dissected map. He did not even have all the bones of a large number of animals to arrange. If he had, the puzzle would have been only like a great many hard dissected maps, all jumbled up together, which he had to sort out and put together correctly. This would have been hard enough, but

his puzzle was harder still. He would have one bone from one animal, and another from another animal of a somewhat different kind, and from these he had to make out what both kinds of creatures from which they came were like.

In his own words, translated: "Mine was the case of a man to whom had been given the imperfect remains of some hundreds of skeletons belonging to twenty sorts of animals. It was necessary that each bone should find itself alongside that to which it had been connected. It was almost like a small resurrection, and I had not at my disposal the all-powerful trumpet; but I did have the unchangeable laws by which living beings were created as my guide, and at the voice of the anatomist each bone and each part of a bone took its place."

If you take notice, you know something of this yourself—that animals which chew the cud, like cows, and have a peculiar kind of teeth, also have cloven hoofs. Darwin has carried this study further even than Cuvier did. He studied all the different parts of animals and their relations to one another. He has made some very curious discoveries in regard to such relations, for example: White cats with blue eyes are

sure to be deaf; and young kittens, so long as their eyes are blue, are also deaf. Some South American horses, instead of straight hair, have curly wool; and these horses have mules'. hoofs. Angora goats, when they have long, curly hair, have long horns; while the hornless ones are found with short hair. A great many curious things of this kind have been observed. You can see that in finding out about animals from their bones, certain of these relations must often be of great assistance where all of the bones of any of the animals he was trying to understand, or "restore," as it is called, had not been discovered.

CHAPTER XIII.

THE DAWN OF LIFE.

After the terrible storms and earthquakes and volcanic fires had done their earliest work in building up the world, a quiet settled down upon the earth. The hot rains that had for so long been pouring down into the hot seas became gentler. The heavy clouds which had hung like a pall over the face of the earth sometimes lifted. A watery daylight shone faintly over the waste and desolate seas, and showed the bare and jagged rocks of the new-born continents and islands.

Under the surface of the still water of the seas and the lakes faint stirrings of life began. The first living things were very simple beings — little more, indeed, than formless masses of jelly, such as may be found on sea-bottoms nowadays. Such beings might have lived by millions, and died and left no sign, as they are doing at the bottom of the Atlantic Ocean

to-day, as they would naturally be easily crushed out of shape, destroyed, and washed away.

Some of them, however, vegetable as well as animal, have horny or chalky or glassy shells. Though the living parts quickly disappear, the shells last for a long, long time. We might expect to find traces of such shells in the rocks that formed the ancient sea-bottom; and so we do find them here and there, but very few and very far between.

"No history is able to write its own beginning." All the earliest histories of different peoples are confused and dim; this is true even of America. When we go back to its real beginning—long before the people of Europe came over and settled it, and before even the Indians they found here were living—mighty nations occupied the land. We have no written histories of these people, but we know they lived here, because we find on the Western plains curious mounds which they raised, and on the cliffs in the mountain countries still farther west wonderful dwellings built upon and cut into the rocks. We do not need written words to tell us that life once existed there; the cliff dwellings tell us that plainly enough.

Just so in the rocks that were once at the bottom

of these old seas we find the dwellings—the shells—in which the earliest life was housed. What sort of life it was we can only judge by studying the life like it which exists now, and by guessing out the secret slowly as our knowledge grows.

A great deal of this scientific guessing has to be done in searching out the truths of nature. I want you to see just what sort of guessing it is. The first trace of a living creature found in the lowest rocks is certainly an animal, or colony of animals, whose shell has been enclosed in the mud, which has hardened over it, and preserved it for millions of years (Fig. 47). And yet, in spite of our knowledge of this fact, we *guess* that plants were created before animals. Why?

Fig. 47.—EOZOON CANADENSE. From Lyell's "Elements of Geology."

Because from a careful study of plant life we find that plants have a power possessed by nothing else, the power of *feeding on* minerals, of living and growing with no other thing to feed upon but earth and air and water. Those were just the things to be found

on our earth at first. Animals have life too, but they cannot feed upon minerals alone. Besides the air and the water, and salt and some other minerals, they must have as food something that has been alive—vegetable or animal food.

You see, then, why we guess that plants came first: because, as the earth then was, the food for plants was there, while, till the plants had come, no food for animals existed. This is no wild and foolish guessing, but a sober conclusion reached through knowledge. I have been so very particular about this because many people who are ignorant of geology — that is, the science of earth-making—are fond of speaking of it with contempt, calling it mere guesswork; and I want you to see just what sort of guesswork it is. Without this kind of guessing the world would still be in darkness on most subjects worth knowing. The only danger in the matter is when the guesses are insisted upon as facts proved to be true.

The vegetable life in the sea-bottom is very different from anything we usually see. The plants there are often mere lumps of greenish jelly, but they have the power that belongs only to vegetable life, of transforming the minerals, earth, and air, and water, into

some material like that they are composed of; that is, they live and *grow*, feeding on minerals alone. Things that are alive, high or low, animal or vegetable, show that they are alive by doing something, and show which they are by what they do. Minerals and metals never do anything; they are acted upon and changed, but they have no power to work changes in other things. That power is something wonderful and mysterious, and we call it life. All things into which God has breathed this power are called *organic*, because they have *organs* by which they live and grow. The rest of the things in the world are *in*organic, not organic.

The vegetable life that came first was all in the water, but it was just the sort of food necessary for the first animals, which also lived in the water. The two lived side by side; you could not tell one from the other, they looked so much and seemed so much alike. The only way you could tell was to wait and see what each would do.

After a while these simple jelly-like forms were followed by a higher kind of vegetable life. Delicate sea-plants floated through the waters (Fig. 48), and were imprisoned in the rocks, where they are found

to-day. Masses of sea-weed growing in favorable spots have been enclosed in solid blocks of stone (Fig. 49), besides many other soft and delicate water-plants.

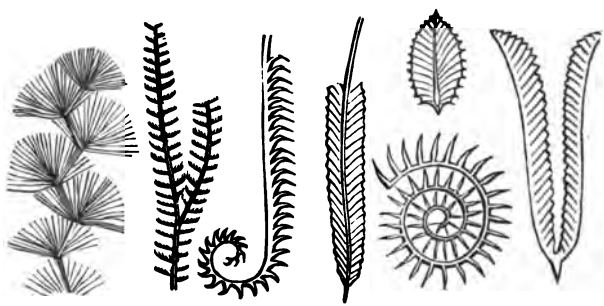


Fig. 48.—SEA-WEEDS AND SEA ANIMALS.
From Hooker's "Mineralogy and Geology."

The way being paved for them, many curious animals also had begun to fill the waters. All very simple, though some were much larger than anything of their kind living to-day. Each age since life came upon our globe seemed to belong to a certain class of being, beginning with the lowest, and growing higher and higher. This time might almost have been called the reign of jelly. As higher kinds of beings came in they did not push out the lower, the jelly-like animals and plants existing in great numbers still, so that the

whole sea-bottoms are covered with them; but the lower and simpler life seemed to sink into less importance when a new reign began.

The most singular creature in the old seas, which might almost be called the king of the jelly kingdom,

Fig. 49.—SILURIAN SEA-WEED.

From Winchell's "Sketches of Creation."

was a queer three-lobed shell-fish. It is known to have had legs, because its nearest of kin living now is formed in somewhat the same way (Fig. 51).

Beautiful star-fish (Fig. 50) swam through the waters of these seas; lovely corals (Fig. 52) crowded the bot-

Fig. 50.—STAR-FISH.

From Lyell's "Elements of Geology."

toms, and slowly grew towards the light; tall and graceful stone-lilies shot upward through the water; gigantic sponges and queer plant-like creatures called grapholites grew in great numbers (Fig. 48). These, though in many respects seeming to be plants, are really animal forms. Shell-fish too, in great variety, lived and died in those old days.

The climate, judging from the creatures that lived

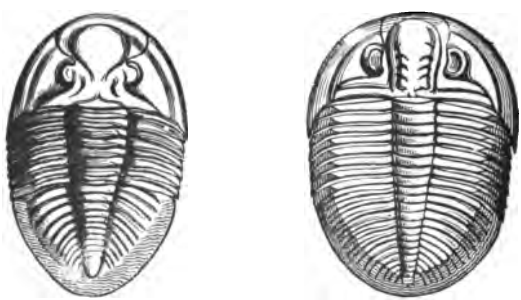


Fig. 51.—TRILOBITES.

From Lyell's "Elements of Geology."

then, must have been rather warm all over the world; the heat from the earth would help to keep the waters warm, and the clouds of mist wrapped the earth around like a blanket, and would not let the heat all escape.

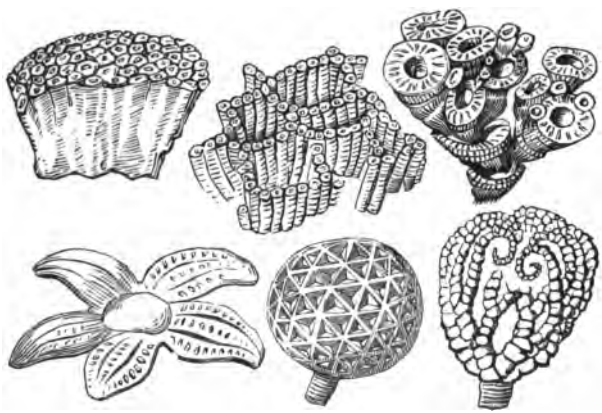


Fig. 52.—CORALS.

From Hooker's "Mineralogy and Geology."

Though the waters were teeming with life, the land remained desolate. Bare rocks and barren sands stood out of the dark waters and under the lowering sky. Not a spear of grass, not a bush, nor tree, nor flower relieved the barren, lifeless stretches, but the time was

drawing near when the earth should be clothed with beauty as with a garment.

The soft and formless beings that filled the waters were not living for themselves alone; they were also preparing the world for the higher and nobler life that was to come.

We have only been watching the dawning of life which had been gently stealing upon the world, but it was as important to the full life that was coming as is the dawn of every new day which ushers in the sun with all the attendant beauty and stir of a full-pulsed life.

CHAPTER XIV.

THE REIGN OF FISHES.

About this time the world was very wonderful, and filled with strange inhabitants. The sun's rays, still struggling through clouds of mist and banks of fog, shone upon wide, shallow seas. Here and there the roll of the waves was broken by bare, jutting rocks, or by low, flat mud-banks. The sun baked the mud, and it dried and cracked and warped up in the heat, till some day a loud rumbling would be heard, the mud-bank crumble up and sink beneath the water, and the waves roll on unchecked over the spot. Somewhere else, before long, another mud-bank would arise, bake in the heated air, crumble away, and disappear.

The inhabitants of this world all lived in the water. They were the flower-like coral animals which slowly, year by year, built up circular islands from the beds of the shallow seas, or lowly, palpitating jelly-fish, dragging their long ribbon-like arms after them, or

star-fish, or creatures living protected, as our clams and oysters do, between two hard shells. One thing, and it is the commonest kind of thing in our world, was not to be found then, and that is a backbone.

This period followed the dawn of life upon the earth; the creatures that now appeared were not only larger, but a higher kind of being.

You know very well, if you ever noticed at all, when you were carefully taking the bones out of a piece of shad or other fish before putting it in your mouth, that a backbone is really made up of a number of separate bones neatly fitted together, to which the other bones are attached. These separate bones, making up the backbone, are called vertebræ. The lower forms of life—those which have no backbone—are classed together, and called *invertebrates;* the higher are called *vertebrates.*

The old world we have been trying to picture was only our world before it was "grown up." Fire and water and ice had not yet finished their part in the work of world-building; but all the while it was making ready for higher kinds of beings, and slowly, one by one, these beings came into existence. There are places here and there in our world nowadays that look

very much as every part of the earth must have looked then. Hugh Miller—the poor Scotch boy you read about in Chapter II. — has studied this part of the world's history very patiently and carefully. He says that, looking off from the rocky, barren coast of the western part of Scotland, you see only bare rocks covered with dismal sea-weed, clumps of it growing on the rocks that are washed over by the waves, long floating streamers rising and falling with the tide; shallow sheets of water, whose beds are covered with other kinds of green water-weeds and shells. All this, he says, is very much what any part of the earth would have shown in the days before the fishes began their reign.

But the dawn of life which first glimmered in these ancient seas did not go out in darkness, it did not even stand still, but grew more and more into the perfect day. It became stronger and spread wider, filling the seas with hundreds of new forms of life, and thousands upon thousands more of the old forms — corals and star-fish and shell-fish; and then came the creatures with the backbones, and the reign of the *vertebrates* had begun. Fish are the lowest of the vertebrates, so they came first. The geologic fish were like, and yet

unlike, the fish we now find. Curious creatures, some of them, wearing, like the knights of old, heavy helmets, or even a complete suit of armor, to protect them against other monstrous armed fish, with which they lived in perpetual warfare.

Fig. 53.—WING-FISH.
From Lyell's "Elements of Geology."

The wing-fish (Fig. 53) wore on its head a heavy helmet, with two holes for the eyes; the body was covered with a coat of mail made of strong plates, and the tail was protected with a flexible armor of bony scales. The tail, which could scull the animal along if necessary, also served as a rudder if he decided to use his paddles to carry him through the water. These were two long arms that projected from each side of his head.

Three kinds of mailed fish are given in Figure 54. No. 1 has the upper part of its body incased in armor; No. 2 has plates of bone protecting its whole body;

and No. 3 wears a queer helmet, made of a single bone. Some of the singular scales out of which the armor is made are given in Figure 55. One of the great mailed

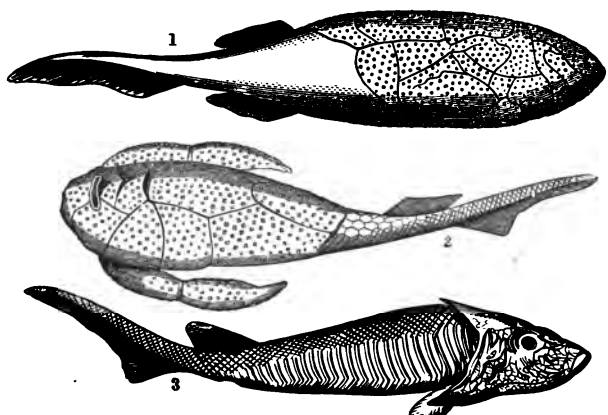


FIG. 54.—MAILED FISHES.

From Hooker's "Mineralogy and Geology."

fish of that time was as large as an alligator; the helmet it wore would cover the front part of an elephant's skull, and was thick enough to turn aside a musket-ball. Though this was truly a fish, it had the jaws and teeth of an alligator.

The rocks belonging to this time are called the old

red sandstone. Perhaps it will interest you to know (as I remember it interested me when I first found it out) that the brown stone of which so many houses and churches are built in this country, particularly in New York City, is old red sandstone. It is wonderful to think that many of the blocks of stone which form,

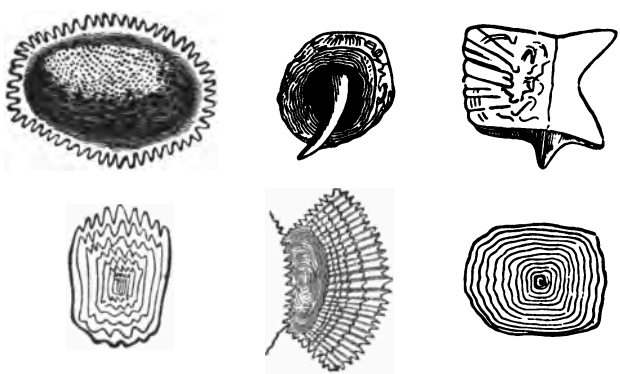


Fig. 55.—Scales.

From Hooker's "Mineralogy and Geology."

perhaps, our own homes hold within them curious fish and shells that lived in these old seas. Hugh Miller tells us of what he found among the rocks of that day, which showed how full the sea was of fish, and how

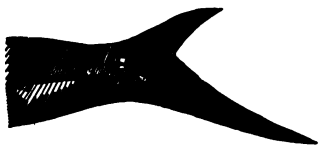


Fig. 56.—UNILOBED TAIL.

From Hooker's "Mineralogy and Geology."

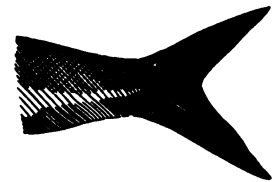


Fig. 57.—BILOBED TAIL.

From Hooker's "Mineralogy and Geology."

suddenly sometimes whole armies of them were overwhelmed and killed by the sudden upheavings of the earth's thin crust. He says that he found what he calls "one of those platforms of violent death for which the old red sandstone is so remarkable:" the layer of rock laid open by his hammer was covered with the remains of a whole fleet of mailed fish, some of them still twisted and contorted as in their dying agony.

Fig. 58.—STONE-LILIES.

Though fish were the reigning kind of life in this age, there were other creat-

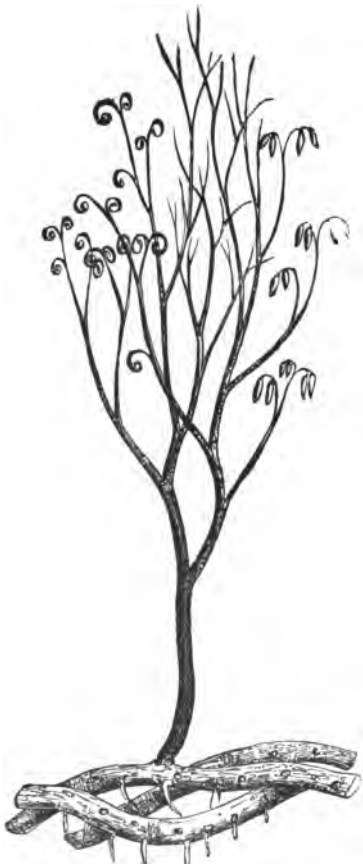


Fig. 59.—PSILOPHYTON.

ures still more beautiful and curious. Along the shallows near the shores of the sea grew great gardens of stone-lilies. These are wonderful creatures — animal, not vegetable; they are cousins of the star-fishes, but they are shaped something like a flower, and grow upon stems (Fig. 58).

The land, too, began to show signs of life; the sea-weeds and a few mosses which had been all the earth brought forth gave place to singular plants, which grew to the size of trees. Figure 59 shows a sort of club-moss, which looks

more as if it had been drawn upon a slate by a very young artist than something that had ever grown and borne fruit as curious as itself. Enormous reeds shot up through the marshy soil, sending out feathery shoots that made them look like giant trees. Forests of slender stems bearing star-shaped drooping leaves covered the mud-banks, and mighty ferns lifted their fronds to the height of many feet.

There were a few trees too, whose rings, which can still be counted, tell that they were a hundred or more years old, and give us a hint that in those old days there were summer and winter, seed-time and harvest, as well as now. You know that the rings which show in a stump of wood show the age of the tree. Each ring is made up of a layer of loose, soft wood, and one of hard wood next it. The loose, soft wood grows in spring and summer, and the close, hard wood in fall and winter. From this we can tell that each year had a season of growth—summer—and a season of rest—winter—and just how many years the tree lived.

The age that is to follow is one full of marvels, and here and there in the time we are speaking of we catch a hint of the coming beauty and glory breaking through the desolation that had so long held sway.

CHAPTER XV.

THE REIGN OF PLANTS.

Down deep in the earth, hundreds of feet below the surface, may be found strange cities, roofed over, walled in, and pillared with what looks like jet-black stone. No light reaches the narrow streets, except here and there where a flaring lamp stuck into a socket in the wall makes a circle of brightness around it, or a tiny flame, imprisoned in a wire cage, and worn in the front of his cap by each of the dwellers in this underground world, sends out a slender flame to light him on his way.

This curious place is a coal-mine, which has been slowly dug out by men who toiled there day after day and year after year, away from the light of the sun and God's beautiful green earth.

I want you to go back with me, in imagination, to the times when the coal was making. We must go back more years than we can even think of to do this.

It was after the reign of the fishes; the land then existing was only low mud-banks and barren rocks, where a few plants and trees were growing. Most of the globe was covered with water, ceaselessly beating upon the desolate shores.

A death-like silence hung over the dreary land and sullen waters. No insect's hum or bird's song broke the stillness of the air. The sounds that might have been heard, if there had been an ear that could listen, were sounds of destruction and death rather than sounds of life. The heavy muttering of the storm, the sudden claps of thunder echoing through the hollow air, the crash of earthquake and volcano, and then silence again, marked by the monotonous roll of the waves, as the silence of night is marked by the regular tick of a clock.

It almost seemed as if the earth, in spite of the heat, had not yet been released from the death-like spell of winter. But at last a new life was beginning to wake. Almost as spring comes to us each year this awakening came to the bare and desert land. Cannot you look back upon last winter and remember how long it seemed?—how you waited and watched for the spring so eagerly and impatiently that it

seemed as though it would never come? At last, when you had almost begun to despair, there came a few soft, warm days, and the miracle of nature was wrought. The whole air was full of the whispers of the coming leaves, murmuring their gladness as they burst from their dark prison-houses in the rough boughs, and pushed their way out into the air and sunshine.

Now that the spring had come to the world, after millions of years of waiting, it brought a wonderful and brilliant life. The excessive heat and moisture together made of the whole land one great greenhouse. The plants grew to a gigantic size. The swampy ground brought forth huge reeds that reared themselves forty or fifty feet high, and were clothed with masses of feathery leaves. Ferns shot up tall trunks crowned with foliage like palms. Singular trees, unlike any living now upon the earth, whose trunks looked like carved columns of wood, filled the forest, and must have given it a most peculiar look.

In this ideal landscape the trees and plants that are known to have made up the coal forests are shown. In the water on the left of the scene are two things peeping up that look like asparagus tips. These are

Fig. 60.—Ideal Landscape of the Coal Period.

From Winchell's "Sketches of Creation."

the growing ends of the reeds that are going to make great trees. In the middle and to the right are some singular round balls with long fringed arms lying out on the water. These for a long time were a great puzzle to geologists, till in some of the coal-beds they

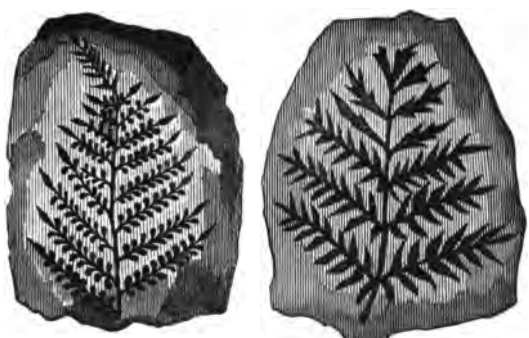


Fig. 61.—Coal Ferns.

From Winchell's "Sketches of Creation."

were found to be the roots of the carven stems near them. The marking on the stems was also found to be scars left by leaves which had fallen off; but the plants that were most common and grew most freely were ferns, both tree and creeping ferns. These plants were all found in the swamps; at the same time on

the rocky lands a few evergreens had sprung up, which were sometimes carried down in the freshets and packed among the living plants of the swamps.

It seems a wonderful leap to make from such a dense living forest as this to a seam of solid coal, lying between layers of stone, hundreds of feet underground, and so it would be if we tried to take it in one jump. But we are able to trace the change step by step from wood to coal almost as perfectly as we can the wood that is stacked, and covered in from the air, and slowly heated till it turns into charcoal, in the charcoal-burner's pits.

Do you remember anything about the peat-bogs we were examining in Chapter VII.—how the leaves and stems of plants, and even stumps and logs of wood, sunk in the swampy waters, instead of turning to dust and blowing away, as they would have done in the air, were packed down and gradually changed into a black, pasty mass, and that this mass when dried would burn? Well, peat is the first step that wood takes in its change into coal.

Coal is nothing but wood—leaves, stems, roots, and trunks—which under water, and by means of heat and pressure, has slowly changed its form. A coal fire is,

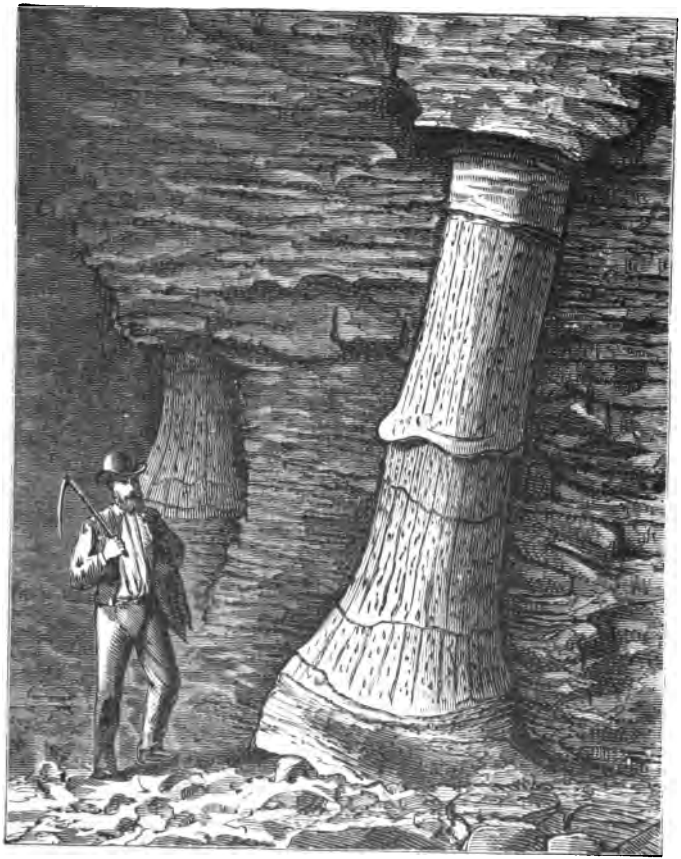


Fig. 62.—Trek-trunks found in a Mine.

From Winchell's "Sketches of Creation."

after all, made from wood, but wood that grew millions of years ago, and was packed away and kept all that time underground, while a wood fire comes from last year's forest that was cut and for a few months perhaps stored away to dry.

We can find in different parts of the world fuel in all its various stages of change from wood, through peat and brown coal and soft coal of various kinds, up to hard coal. Two other things that we do not think of as coal form links in this chain of change. Jet, out of which jewellery is made, is one form of soft coal, and graphite, that makes the best lead for lead-pencils, is the hardest of the hard coals.

A piece of common coal ground down into a thin slice shows under the magnifying-glass just the sort of cells that a piece of wood cut thin and even will show. Perfect leaves are often found in coal, with every vein distinct; and in some coal-mines great tree-trunks of solid coal, embedded in coal as solid, have been found (Fig. 63).

You remember the sudden changes in this old world were something like what happen now, only more violent and more swift. The coal swamps lay usually near river-mouths. Besides the leaves and fallen

trunks from the forest where they grew, the river in its uprising would carry down masses of logs and uprooted trees, and pack them in among the living plants, and over all would settle loads of river mud and sand brought down by the freshet. Something like this is going on at the mouth of the Mississippi and other rivers now, and peat-bogs are forming there as the coal-beds began to form so long ago.

Coal seams are large, flat layers of coal pressed between layers of various kinds of rock. Usually there are many layers of coal with layers of rock between, like a natural jelly-cake, the jelly being the coal, and the cake the thick rock between. Each layer of coal represents a buried forest, and the layer of stone just under it is crowded with the roots and stumps standing just as they grew millions of years ago. In Wales, in one place, there are one hundred layers of coal, with rocks between, one on top of the other, for over two miles deep.

Though plants reigned in the coal-measures, the waters were not empty of animal life: great fish swam about in the waters, beautiful corals clustered on the rocks near the sea surface, star-fish and stone-lilies, shell-fish and lobster-like creatures, dwelt in the

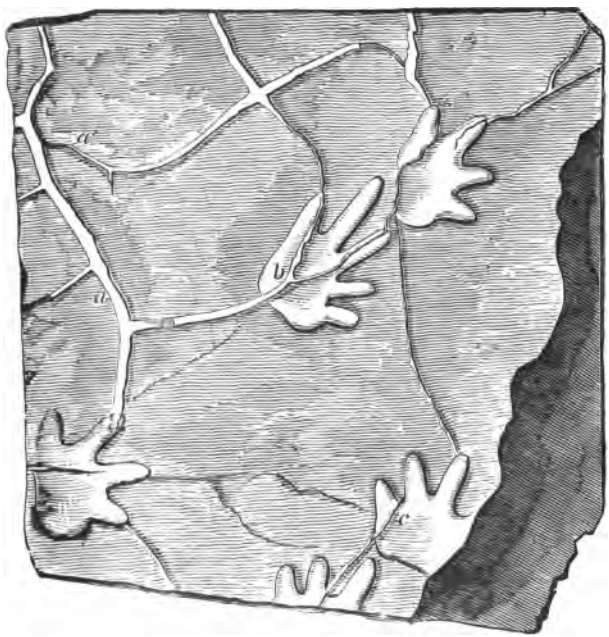


Fig. 63.—Slab of Sandstone showing Footprints of Saurians.
From Lyell's "Elements of Geology."

sea. A few insects had begun to flit about over the surface of the water, and enormous lizards made their appearance. Clumsy footprints on the sandstones (Fig. 63) show where they have lived and swarmed,

and singular skeletons leave in the rocks a record of their deaths. A new and higher life had begun in the animal world while the coal forests were growing and perishing and being packed away for future use.

After the end of this period the earth, with its great beds of forest and forming coal, suffered terrible convulsion. Again the crust was thrown into wrinkles. The mountains of our Eastern States were thrown up at that time, and then the water began wearing them down. The animals and plants of the coal period began slowly dying out. It was like the twilight of the day that had dawned so long ago; but it came before a time of comparative rest, and the dawn of a new day.

CHAPTER XVI.

"*STRIKING OIL.*"

THE expression "striking oil" is such a common, every-day phrase that we hardly stop to remember what it really means, and yet thirty years ago such a term was never used, for the very fact that gave rise to it did not exist.

A hundred years or so ago a curious sight might have been seen in the Indians' country of western Pennsylvania. Early in the morning one of the squaws would carry a dirty blanket down to the borders of the stream. A natural conclusion would be that she was about to give her blanket a much-needed washing. But no; instead of dipping the blanket in the water and rubbing and squeezing and wringing it, she merely flings it out on the surface of the stream, and when it becomes soaked draws it towards her and begins carefully squeezing out the liquid that it has caught in its meshes into a gourd. The

observer begins to catch the idea. It is not a clean blanket that she wants, but the disagreeable, ill-smelling, greasy scum that floats upon the surface of the water.

In this simple manner and by these queer means the Indians of that time collected oil, not to give them light, but to be used as a liniment to rub their poor joints when swollen with rheumatism. This was the old savage way of "striking oil;" for this oil gathered was petroleum, which is now so commonly known as kerosene, but was then called "Seneca oil," and used only as a medicine.

A certain Colonel Drake, who had a farm in that part of the country, came to the conclusion that somewhere in the earth was to be found a reservoir of oil, which he could reach by digging for it. He believed that the oil which oozed out of the rock and made a greasy scum on the Oil Creek waters came from somewhere, and that somewhere he meant to discover. His neighbors amused themselves by laughing at him and joking him, much as Noah's neighbors did when he was building the ark. Their tune was changed, however, when in the summer of 1859 Colonel Drake "struck oil." In the course of four months Drake's

well had poured forth two thousand barrels of oil. Then the nation took the oil fever. Speculators rushed in, new wells were dug, and the once desolate fields bristled with derricks.

Before Drake's well was dug, manufactories were in existence in which oil was distilled out of coal, and called coal-oil. Petroleum was found to be so like this substance that it too is often called coal-oil, and supposed to be distilled in the great workshop of nature out of coal. But that idea is incorrect. It is not made out of coal, but it is closely connected with coal in this way, that both coal and petroleum are made from the plant life of the past, which in the course of ages has been changed into these two substances. If coal-oil were made out of coal, it would be found near the great coal-beds. This, however, is not always, not even usually, the case.

We have seen how the coal-beds were formed by the great swamp forests, which, under fresh-water and by means of great heat and pressure, were turned into coal. Oil, it is thought, is formed by the softer plants, sea-weed and water-plants, which have been, under salt-water and at a lesser heat, distilled beneath the surface of the earth. The oil being formed in the

water, of course floated on the top. Sometimes it soaked into porous sandstone, sometimes it ran into holes and fissures of the rocks. Usually it is found associated with the salt-water under which it was gradually formed.

I have said that oil is distilled out of plants; it is also distilled in much the same way from the animal life of the past; but we probably owe most of what is sold to a distillation of plants. The rocks of many periods, besides that when plants grew in such enormous quantities, are full of oil. In the coal-beds, you remember, we found every kind of coal showing the gradual change of vegetable matter into coal—from peat through soft coal to hard coal. In the same way petroleum is found in all the different forms it takes on in its change—light oil, heavy oil, bitumen, and last, it is thought by some, diamond. If a great mass of vegetable matter is heaped up and left, and after a while examined, in the middle of it is found an oily, tarry substance, like one of the forms of petroleum—bitumen.

With the oil and the salt-water in the underground pools there is found a quantity of gas formed from the petroleum. And it is this gas, which is very much

squeezed up, that makes the oil spout up when a boring reaches the reservoir. When water and oil and gas exist together in the same crevice of the rock, the water, being heaviest, will lie at the bottom; on top of that will be the oil, and above both of them the squeezed-up gas (Fig. 64).

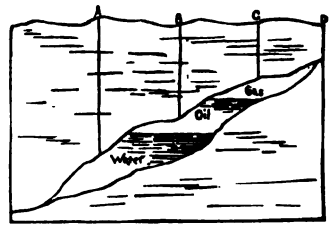


Fig. 64.—Oil Pool under the Earth.
A, water well; B, oil well; C, gas well; D, surface of the earth.

Now you can see that if a well is dug at A, the crowded-up gas will force up water in trying to get room for itself. After the water has all come up, if the gas is still very much compressed, the oil, which has run down to B to take the place of the water, will follow the flow of water. If the power of the expanding gas has gone, the oil must then be pumped up. If, however, the well has been dug at C, gas comes up, and oil must be pumped up when the gas has all escaped.

Natural gas is used to a great extent to light and in part to heat great cities in the coal and oil districts. It seems as though the supply must soon give out, but

as a matter of fact it seems to be nearly undiminished in places where the wells have been blowing off gas for nine years. And if it should give out, the pipes being all laid, it is possible to make a kind of cheap gas at the mines which can be carried and used as the natural gas has been.

The oil is certainly failing in the old fields. New fields may of course be found, and probably will; for the oil that has been burned all over the world until a short time ago came mainly from a strip of land only one hundred and fifty miles long, and from two to twenty miles wide. But of late years there has been a wonderful discovery of oil in Russia, where wells have spouted the incredible amount of fifty thousand barrels a day.

The great works that used to distil coal-oil have been turned into refineries of petroleum (Fig. 65). After the kerosene has been made, a thick, tarry, disagreeable stuff is left. This looks like the most hopeless sort of material for any use, but out of it are made our modern "wax" candles, "wax" matches, and even some sorts of candy and chewing-gum. Another of the materials left when the kerosene is taken out is made into beautiful dyes—colors that were never

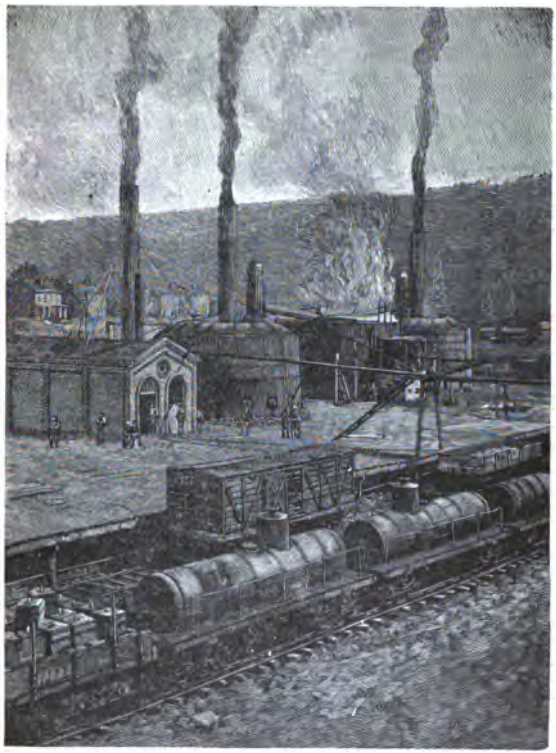


Fig. 65.—Oil Refinery, showing Tank Cars.

seen in old times. Unfortunately these colors do not hold like the simpler old-fashioned dyes, but often fade out, or, what is worse, fade into very ugly tints.

Much of the oil is brought from the region where it is found in curious tank cars, but some of it is pumped through pipes three hundred miles long, from the mines to the refineries. Beside the track of the Central Railroad of New Jersey such a pipe runs. If you ever chance to go over that road to Long Branch or Philadelphia, or to some Jersey town near New York, notice this pipe, and you may hear the oil from three hundred miles away give a thud, thud, as it is pumped into the reservoirs at Bayonne. If you look to the eastward, about six miles below Jersey City on this road, you will see a branch track curving off to New York Bay, where it ends in a forest of masts and factories and great oil tanks. Many a time you may see from New York the whole heavens ablaze with the fire from a tank that has been struck by lightning or has caught on fire some other way.

A still more wonderful sight, however, is to see a natural oil well ablaze. One of these wells at Cherry Grove, Pennsylvania, in the summer of 1882, was sending out oil at the rate of a thousand barrels a

day. By some accident it took fire, and for four days and nights it shot up into the air a blazing fountain, breaking into millions of fiery drops, the great column of fire swept here and there by the passing winds. The fire at last was quenched by shoot-

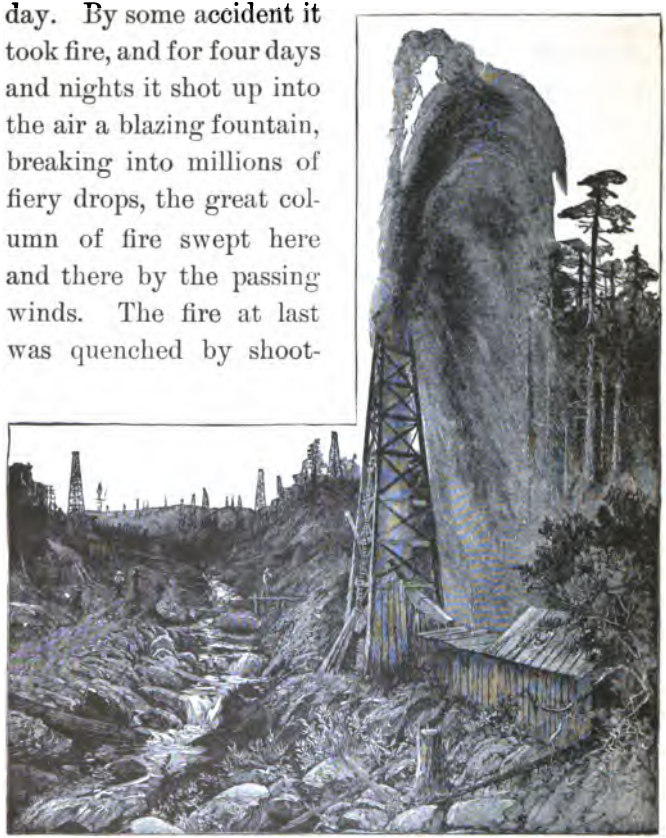


Fig. 66.—A Field of Derricks.—Effect of a Torpedo.

ing off with a cannon-ball the top of the tube out of which the oil was spouting, and plugging the pipe below the blaze; but some of these wells have gone on burning till all the oil which they contained has been consumed.

CHAPTER XVII.

SALT.

In the Holy Land there is a great cleft which runs north and south, and ends near the southern part of the country. Just before the end it dips deep into the earth, more than a mile lower than the level of the Mediterranean Sea, not far away. Through this cleft flows the river Jordan, and the deep gouge into the crust of the earth is the bottom of the Dead Sea. This sea, called in the Bible the Salt Sea, is one of the most curious bodies of water on the face of our earth. If you came upon it in your travels it would not seem so wonderful. Under the bright sun of Syria you would see a beautiful sheet of blue water rippling under the breath of the breeze, bounded on either side by bare, rugged mountains, with scarcely a blade of grass or tree to break the solitary, barren grandeur. It is not horrible and greasy to the look, nor disgusting to the smell, as many old writers used to say—though the

shores are covered with a brown, pitchy substance called asphaltum, and great masses of salt and sulphur and gypsum, or plaster of Paris.

The water is so heavy with these substances that a man can scarcely sink in it, but when he tries to swim will find himself almost out of the water, and his feet kicking in the air. A curious old writer, who visited the Dead Sea before Columbus discovered America—in fact, more than four hundred years ago—says, "It is called the Dead Sea because it does not run, but is ever motionless. . . . And you shall understand that the river Jordan runs into the Dead Sea, and there it dies, for it runs no farther."

In this sentence he tells us the secret of the sea. The river Jordan does run into the salty lake, hemmed in by high mountains on both sides, but there is no way for the water to get out.

You know when water is put in a shallow vessel it will dry up; that is, it will pass into the air in an invisible steam, or vapor, and the vessel will be left dry. If you take some water in which a great deal of salt has been melted and let it dry in the pan, the water will dry away, leaving the salt behind. Suppose every day from your pan of salt-water ten spoonfuls of water

dried away, and you each day put nine spoonfuls of fresh-water into it, there would be at the end of each day a little less water in the pan, and it would be a little saltier to the taste. Now, this is just what happened to the Dead Sea. In the first place, the sea was probably an arm of the Mediterranean, which was cut off from it by the lifting up of the land between. This salt lake would soon have dried up, leaving a flat cake of salt where its bottom had been; but the river Jordan pours into it "and dies," as old Sir John says; but in dying it leaves in the water of the sea all the dissolved earth and salt and other things it had brought down in its current. More water dries out of the sea each day than the Jordan and other rivers bring to it; so the sea for long ages has been slowly shrinking and growing saltier. Along the old sea margins there are cakes and blocks of salt, as well as asphalt and sulphur, left by the retiring water; and at the bottom of the sea crystals are forming and settling down from the intensely bitter salty water.

It has been long believed that the Dead Sea covers the cities of Sodom and Gomorrah, but that is a mere guess. That the cities were to the north of the sea is believed by people who have studied it very carefully,

and the "slime-pits" mentioned in the Bible were pits of asphaltum or bitumen. You remember that I told you in the chapter on oil that it was distilled from vegetable matter under *salt-water*. This asphalt is only one of the harder forms of oil, and here we find it close to the beds of salt.

There are other salt lakes in the world something like the Dead Sea, but none that are so curious or interesting. The Caspian Sea is a sea without an outlet; but from what we can find about it by studying its shores, it may never have been a part of the great ocean, but formed and made salty by the drying up of river-water age after age, leaving the settlings to accumulate till the water of the Caspian is salty. It is plain to be seen that the Caspian has shrunk a great deal owing to the same fact that has caused the shrinkage of the Dead Sea, that more water is lost by drying than is gained by the river's tribute. Still, with all this loss of water, it is not so salty as the Mediterranean. This is one of the reasons it is not thought to have been an arm of the sea cut off, though it is not quite certain.

Great Salt Lake, where the Mormons live, is a sea like the Caspian, mainly made by the rivers that empty into it and pass away in vapor. Ages ago Lake

Champlain was part of the sea, and the waters were salt; but the fresh-water rivers running into it and out again at the lower end have rinsed out the salt and left it sweet.

Salt lakes almost always have other settlings forming layers at the bottom besides salt. One of these is plaster of Paris, or gypsum. This is dissolved in the water of the lake, but as the water becomes more and more salty it finally settles; then, as the water gets all the salt in it that it can dissolve, salt begins to settle above the gypsum, and we generally find a layer of gypsum and then one of salt, and dirt washed down by the summer floods over them both.

Just as under coal-beds iron is found, so under salt-beds gypsum is found. The salt accumulates in great masses and cakes. Sometimes it is lifted by fire up into mountains; and at the lower end of the Dead Sea there are great masses of salt reaching several miles in length, and in some places four hundred feet in height. The rain-storms have worn and melted it till it stands in buttresses and pillars. At the foot of the hills these monuments stand, strewn around with great lumps of pinkish salt, soft and slushy in winter, but sparkling with brilliant crystals under the hot summer's sun.

In Louisiana, among the low prairies, where Evangeline, in Longfellow's beautiful poem, sought her lover, there rise five humps of land partly surrounded by water, called islands. One of these contains one of the most wonderful salt-mines in America. During the war the terrible want of salt made the owner of this island dig for it. After digging for days, some hard substance was struck, black and solid. It was at first thought to be a stump, but a few blows of the pick and out flew a pure white piece of salt. It had been covered with a coat of black asphalt. It is not known how deep this salt-bed is, but no bottom had been touched after digging through sixty-five feet of pure salt. At one place in Europe a mine has been sunk for one thousand feet and no bottom found.

Near where famous old Troy stood are some marvellous salt springs. The place is a valley enclosed in mountains, colored by the minerals in the water—gorgeous reds and blues and yellows. The floor of the valley is a variegated crust, through which jets of hot, intensely salt water come up. In one place from the rocks at the side jets of boiling water spout out like fountains at play, and flow away as a rivulet of salty, steaming water.

CHAPTER XVIII.

THE REIGN OF REPTILES.

One summer, about a dozen years ago, I was visiting Hartford, Connecticut. A number of people meet together every summer in some part of the United States, to discuss questions of science. After the science is over the members of the association often go upon excursions.

One day during the Hartford meeting the geologists and others paid a visit to a very wonderful place on the Connecticut River, near Middletown, called the Portland Quarries. Quantities of brown stone for house-building had been taken out and shipped to various places. This quarrying had been going on for about one hundred years.

In one place a broad, uneven floor had been left littered over with slabs of stone of various sizes. On the broken bits and on the floor were great numbers of the most wonderful footprints, as clear and distinct as if they had been made an hour before in wet earth.

Some of the tracks were eight or ten inches in length, others were not more than four or five. The tracks looked like those of gigantic birds, and were called for many years "the bird-tracks of the Connecticut Valley."

The sandstone quarry had once been the beach of a shallow sea. Over the sand which had been left wet by the receding water myriads of strange creatures roamed in search of food. More than fifty different kinds of creatures have left a record of their presence on this shore, and there were probably hundreds upon hundreds of each kind. On this single slab of stone, six feet by eight, and dug from one of the quarries of the valley, are the tracks of six different creatures, inhabitants of that ancient world (Fig. 67).

Before the footprints had lost their distinctness, the next tide, rising and sweeping inland, carried a new supply of sand and spread it over the beach, covering the footprints and making a fresh, smooth surface for new ones. So layer after layer was formed, each holding the record left of their presence by the visitors of the day. Slowly the whole mass hardened into stone, keeping through thousands of years the marks impressed upon it when it was yielding sand.

The sandstone readily splits between any two layers. When an upper slab is turned over, the same footprint is found upon it as was upon the one below it, only the print is *raised* instead of being hollowed

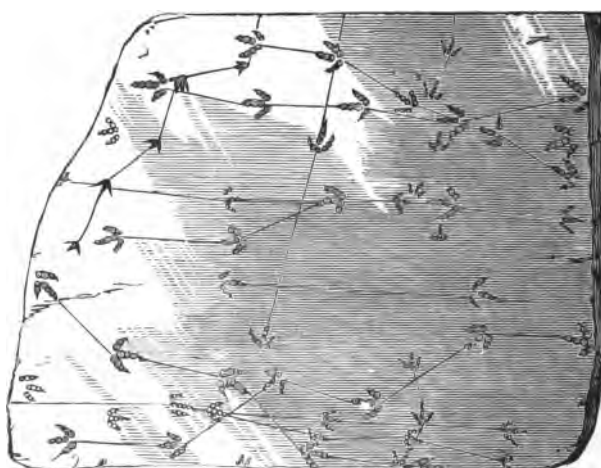


Fig. 67.—Slab of Sandstone, with Tracks of Bipeds.

From Winchell's "Sketches of Creation."

out, just as the sealing-wax on a letter shows the same figure *raised* upon it which was hollowed out on the seal that pressed it.

The markings so long considered to be bird-tracks

are now thought to have been made by a strange winged reptile with bird-like claws, whose bones have been found in the rocks of that time. It is not so singular as it may seem at first glance that such doubt exists. Reptiles and birds are nearer cousins than one would be apt to guess. They are really only two branches of one great division of the animal world. Now, it is true, we find them very widely separated, but if we could see some of these old-time monsters it would puzzle us to tell whether they were birds or reptiles.

These tracks in the sandstone may have been made by a reptile-like bird, but more probably they were those of a bird-like reptile.

When a reptile is spoken of, the idea it suggests is a snake, as snakes are the commonest of the reptile class in our time and our country. There are, however, many creatures living on the earth now which are just as truly reptiles as snakes are; we may not see many of these creatures, but we often hear or read of them—crocodiles, and their American cousins alligators, turtles or tortoises, and lizards. These do not form a very important class in the animal kingdom now, but there was a time in the world's history when

they were the rulers everywhere, in the air and the sea and the land. There were probably more in number and more in kind than the world has seen before and since, and besides this, they were enormously larger, more powerful, and more dangerous. Many of these creatures were forty feet long, and some were as much as sixty or seventy feet.

The reptiles that ruled in the air were utterly unlike anything we now see. Some of them were twenty feet from tip to tip of their out-spread wings. One of them, you see (Fig. 69), has just thrown himself from a rock in pursuit of a dragon-fly, while his companion sits perched above him on the top of the bank.

Another of these singular creatures may be seen in Figure 70, leaving behind it, as it walks, the prints of its bird-like claws and sharp tail and queer wings. The wings, you see, are nothing like a bird's wings; they are more like those of a bat, the skin being stretched to a bone of the fore-foot from the side of the body.

Terrible frog-like animals roamed over the land, leaving footprints curiously like the impression from a flat human hand (Fig. 72).

The shores of the ancient seas were infested with other huge beings something like our alligators. In

Fig. 68.—Ideal Landscape of the Age of Reptiles.

From Winchell's "Sketches of Creation."

Fig. 69.—The Pterodactyl.
From Winchell's "Sketches of Creation."

the landscape (Fig. 68) one of these may be seen, in the middle of the picture, crawling up on a rock, while the huge frog-like reptile is making his lumbering way down to the water, where he spent most of his time.

It was the ocean, however, in which most of the monsters of that time lived. The waters of its seas were lashed into fury by their sports and spoutings and battles to the death. Such a battle is shown in

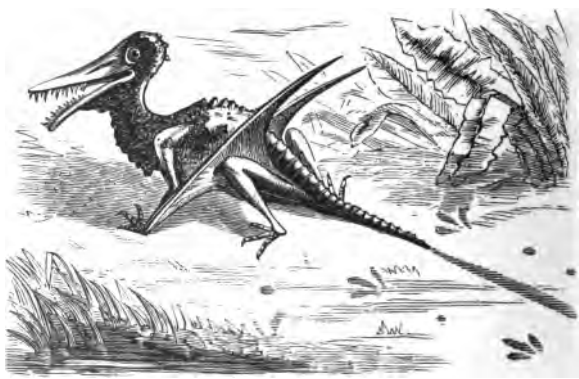


Fig. 70.—RAMPHORHYNCUS—ONE-QUARTER NATURAL SIZE.
From Winchell's "Sketches of Creation."

the picture (Fig. 71). The larger, to the left, must have been a terror to the watery world around him. Not content with devouring all the fish and lizards that came in his way, he also lived upon the young of his own kind, as the bones found in the stomach of a skeleton show.

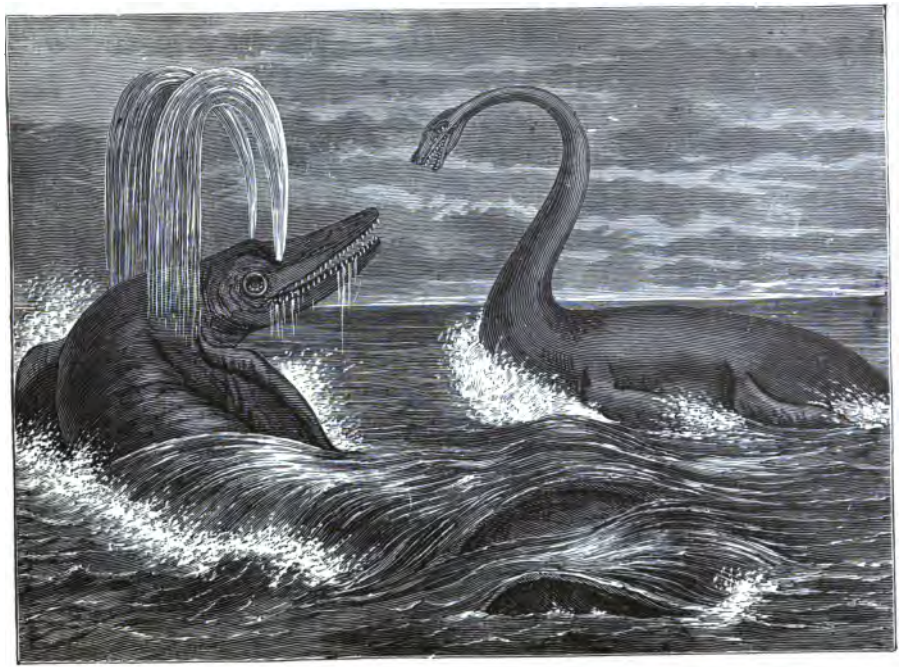


Fig. 71—ICHTHYOSAURUS AND PLESIOSAURUS.
From Winchell's "Sketches of Creation."

The huge sea-lizard to the right in the same picture was a much less dangerous creature. At this time there existed creatures more nearly approaching serpents; these have sometimes reached a length of eighty feet. It is *possible* that some of his cousins still exist in the ocean, and that they occasionally show themselves. There have been a great many stories of sea-serpents seen by many people and at various times. Most of these are undoubtedly sailors' yarns, and deserve no attention; but leaving these out of the question, there still remain some that we cannot refuse to credit—one of these, for instance, where five hundred people saw the creature again and again, and near enough to distinguish its eyes; and some of these witnesses were men whose evidence would have been taken in any court of justice in the land. Not very long ago a strange carcass was caught in the anchor of a sailing-vessel and beached on the Florida coast. A storm washed it away before such drawings and measurements could

Fig. 72.—TRACKS OF LABYRINTHODON.

From Lyell's "Elements of Geology."

be made as would have settled the question as to what it was. Now that people are seriously beginning to listen to stories of the sea-serpent, we may hope that some day one will be captured, and then all doubts as to its existence and what manner of reptile it really is will be finally set at rest.

During the age of reptiles many new shells and stone-lilies, etc., first appeared in the waters; but they were not sufficiently unlike those that had already come and those that followed after to require description here.

The character of the forests, too, was changing all the while from what it had been in the coal-making period. The great club mosses with their carven stems, and the huge, feathery-leaved reeds, were passing away. The ferns still grew in great profusion; both the low and creeping kinds and the tree-ferns filled the woods, but other trees and plants, like our evergreens and palms, took the place of vanishing kinds. These, too, made coal-beds, though not such vast ones as were stored away during the reign of plants.

It must be understood that the whole world, Europe and America and Australia, had each its history, when the reign of water and fire and ice, of plants and ani-

mals, followed each other very much in the same way, but not at the same time. Europe is an older country than America, and America is older than Australia, in other things besides those about which our written histories tell us. The animals and plants of America when it was first discovered were like those of Europe in a time much earlier. Australia had animals and plants that corresponded with an age still earlier than those of America. Some of the curious birds and animals of Australia help us to understand the meaning of the singular skeletons dug out of the rocks in European countries.

In the history of each country, after man came upon the earth, we see something like this. When Rome was in its later days, England was full of barbarians; and England was an old country, in her turn, when America was still barbarous. Just as man's work in the world — his diggings and minings and quarryings—changes the order of nature in the layers of the earth, so his moving in and taking possession of the new countries changes the order of things there too, and interferes with the regular succession of creatures which would have followed, one kind succeeding another till all was complete.

CHAPTER XIX.

THE BOTTOM OF THE SEA.

About three-quarters of our world is under water. This we all know very well, if we have not grown so old or so wise as to have forgotten our geography. We are apt to think of this vast expanse of ocean as having very few inhabitants; in fact, as being a sort of watery great desert, with fish passing through it, something as the caravans pass over Sahara. It is chiefly important to us as the path-way over which steamships and sailing-vessels go, carrying passengers and exchanging the products of one country for those of others.

But the ocean is even more than the land teeming with life. Not only are its waters full of darting fish, but there is a silent life filling the sea-bottom, and doing more towards building it up than all the larger creatures above. And so it was in the past ages, only more truly so. Large as the ocean is now, it was far

larger then. The Atlantic waves as they swept westward did not break upon the coast of the British Islands, for England, Ireland, and Scotland were deep down under water. The inhabitants of the British Isles in that day were principally little shell-fish, so tiny that you could not have seen what they were with your unaided eye. As each generation of these little creatures died, these shells, some of glass and others of a limy or chalky substance, beautifully formed and delicately carved, dropped to the bottom, and so built up the earth. There was nobody around then with his magnifying-glass to look at the curious earth as it was forming, but it has been saved for us in one of the great layers of earth called "the chalk." Much of England was built up in this way by the dropping of myriads of shells when the little life that had animated it went out. At the end of the English chalk period Great Britain and more besides were lifted bodily above the waters, and then the waves went to work to carve England, with all her bays and inlets, out of the great stretch of uplifted land. The Strait of Dover was cut through, leaving the edges of the chalk layer standing up, white and tall, facing the water.

Fig. 73.—Chalk Cliffs of Dover.

These chalk cliffs gave the poetical name of Albion, or *the white*, to England; and these were the shores to which the men of Tyre and Sidon came in their ships to gather the tin found in the southern counties

of England, and carry it away to their own land, long before our Lord was born in Bethlehem.

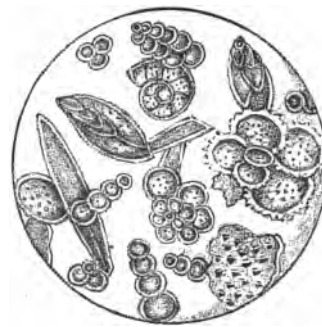


Fig. 74.—English Chalk.

Though England was no longer receiving new layers of shells, the same thing went on and is going on to-day in portions of the Atlantic Ocean. The difference between the chalk formed so many millions of years ago and that forming now you can see by looking at Figure 74, from the English chalk-beds, and then comparing it with Figure 75, from the bottom of the Atlantic to-day.

Fig. 75.—Atlantic Dredging.

Very little was known of the great oceans before the days of Columbus and the other voyagers of his time. All the sailing done before that was in inland

seas like the Mediterranean, or along the shores. And people imagined that down in the depths the cold and darkness and tremendous weight of the water would prevent anything from living there. A few examinations were made, it is true, in a part of the Mediterranean near Greece, and no life being found there, that settled the question for a while.

But just thirty years ago men of science found occasion to change their minds upon this point. A telegraphic cable which had been lying in deep water (the exact depth was known) was broken. In order to mend it the cable had to be drawn up out of the water. When this was done, thousands of tiny living creatures were found on the wire. Not loose, as though they had been caught on the cable as it was dragged up through the waters, but closely cemented to it, showing that they had lived where the wire was lying in the depths of the sea.

As soon as the fact was known that there was life in the sea-depths a great interest was aroused. Ships were fitted up with all sorts of dredges and scoops and nets to catch the delicate creatures living down deep in the water, and to bring up the soil from the bottom so gently that its inhabitants would not be killed.

Day by day the formation of chalk, as it is going on now at the sea-bottom, was watched and recorded.

Nowhere else do we find a link that binds our world of to-day so closely with the far distant past as just here. The higher the form of life, the more easily does it change and develop. We find in the mud from the Atlantic bottom living creatures whose shells are very much the same as those which millions of years ago built up the English chalk. These are almost unchanged, while above them all the wonderful panorama of life has passed unnoticed. The strange fish and monstrous reptiles and curious reptilian birds have all passed and vanished utterly from the earth, the water and the air knowing them no more.

The reason of this is clear. All life depends much on its surroundings: if they remain the same, the forms of life usually do not change much. On land and on the surface of the water the surroundings constantly vary. Heat and cold, moisture and drought and plant life, have changed, and the animal life has changed with them, but in the depths of the sea there has been only one marked change—the waters have been slowly cooling off, and so the changes have been slight and gradual. Everything else remaining the

same, we ought not to expect, and we do not find, any violent change in the forms of deep-sea life. The geologic period of the Atlantic depths is therefore not far from that of the British Isles some millions of years ago.

It perhaps seems like going backward instead of forward when we take up the study of these tiny, simple forms of life, after the mighty reptiles that have ruled with a rod of iron the world of waters. But we are going upward through the layers of rock, and after the coal-fields and the rocks that contain the foot-prints and bones of the reptiles, come these beds made of tiny glass and chalky shells. The reason of this is that great tracts of land sank under the sea, and over it settled myriads of the chalk shells, forming a thick layer. These little creatures had been living from the earliest ages. Indeed, the *Eozoon*—the dawn-animal—the earliest form we know—was cousin to these sea-shells, which you may see in the illustration called English Chalk.

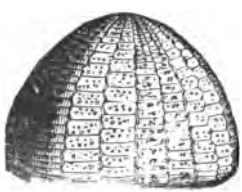


Fig. 76.—ECHINUS (Fossil Sea-urchin).

From Lyell's "Elements of Geology."

Though these tiny shell-fish made so much of the land at that time as to give a name to the period, *the chalk*, there were existing at the same time a great many other forms of life. Sea-urchins abounded (Fig. 76), and corals (Fig. 77), and other shell-fish (Fig. 78), also other forms, called glass sponges, living with shell-fish as they do now.

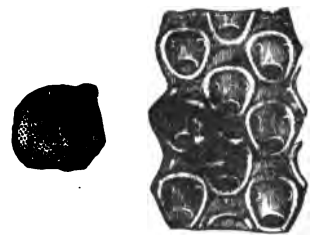


Fig. 77.—Corals of Chalk.

a, Natural size; *b*, Part of the same magnified.

From Lyell's "Elements of Geology."

Turrilite.

Scaphite.

Fig. 78.

From Lyell's "Elements of Geology."

In the depths of the Philippine seas, nearly three-quarters of a mile straight down, live the most beautiful of the glass sponges nowadays. They are almost the most beautiful of all nature's works—long curved cornucopias made of the finest spun glass woven into a square-meshed lace. Around the horn run

short frills of delicate lace, while the small end of the horn is enclosed in a tuft of the silvery hair. This beautiful thing is second-cousin to our common drudge of a sponge, and nearer still to the glass sponges among the chalk (Fig. 79). Whenever you are in a museum, ask to see the Venus's Flower-pot, for that is the name of this particular kind of a glass sponge.

Fig. 79.—Sponge of Chalk.
From Lyell's "Elements of Geology."

While the earth was being slowly built up by these beautiful beings under the sea, you may be sure the land was not empty. Enormous lizard-like creatures wandered over the shores or slipped heavily into the water. Great flying lizards beat the air as they rushed downward from some high tree or lofty rock. There were fifty different kinds of immense snake-like creatures, some of them eighty feet long. The reign of reptiles was drawing to a close, but it was not over. There are on the earth now only six large kinds of reptiles, and these not over twenty-five feet in length.

There were still very few beings above the reptile class, but the highest forms were beginning to be shadowed forth by a class, the lowest of the quadrupeds, to which the kangaroo and opossum of our time belong. These creatures have a pouch in which the unformed young are kept till they are fully developed.

The climate must have been warm all over the earth. The plants and animals that existed in all parts of the world in those days live only in the hottest countries now. The forests through which the reptile monsters roamed were made up of tree-ferns and palms, in the island of Spitzbergen, where there is now perpetual ice and snow.

At the end of this period a great change took place in the New World. North and South America had been up to this time two islands, widely separated. By an uplifting of the western part of the two islands the land that connected them under the sea was raised above water, and the continent of America was born out of the sea. This was the age of continent and mountain making. A map of America before this upheaval, and one afterwards, do not look as though they were made to represent the same world, they are so very different.

CHAPTER XX.

BIRDS OF THE PAST.

One period in the building up of the earth we have called the Reign of the Fishes, for two reasons: first, because the greatest and most terrible of living creatures were of the fish tribe; second, because the fish were at that time the highest kind of animal living. Another and a later period was for the same reason called the Reign of Reptiles. Other and lower creatures lived in great multitudes, but the reptiles were the mightiest.

Birds lived in geologic times, too, quite as wonderful and monstrous as either fish or reptile, but there was no one time that could be correctly called the age of birds. They never had a distinct reign of their own.

This seems a little strange, for there is no class of living creatures that seems so entirely distinct and separate from the rest of the animal world as birds. They have so many peculiarities all to themselves;

their horny bills and feathers and wings, their power of flight and of song, seem to set them apart from other living beings. And so we might very naturally expect to find in the past a reign of birds.

You remember that the arrangement that was given to the different kinds of living creatures by naturalists, beginning at the simplest kind of life and going gradually up, was found, when geology began to be studied, to correspond very nearly with the order of animal life found in the rocks, beginning at the lowest; that is, men studying the works of God, and arranging them in classes, followed almost the same order that God had followed in creating them.

But there was one point where the order of science was found to be different from the order of nature. Men put birds next after reptiles, while in the rocks they were found to be side by side. This looks as if there must be a mistake somewhere. But there is no mistake; in this seeming difference is hidden a wonderful natural truth. Birds, as we know them now, seem quite as far removed from reptiles as they are from fish or from quadrupeds; but this is only seeming. Birds are, as a matter of fact, only one great branch of the reptile family; but they have been sep-

arated so many millions of years that the family likeness is not very strong. That they once belonged to the same family, geology, more than anything else, tells us.

Fig. 80.—Bird like Reptile.

Don't you remember, in Chapter XVII., the Reign of Reptiles, the curious footprints that were sometimes taken for bird-tracks and sometimes for the tracks of reptiles? Well, they were made by creatures that had a good deal of both bird and reptile in them. Their footprints told the tale. In Figure 80 you see the outline of one of these queer bird-like reptiles, and there were many others, as well as reptile-like birds.

The manner in which such tracks were preserved in the sand, and retained when it was baked and pressed into stone, is very easy to understand. Where the

tracks are found was a shallow inland sea, connected with the ocean by a narrow strip of water. The tides flowed in, deposited the sand that they had swept up with them, and then flowed out, leaving a coating of wet, smooth sand behind. This is shown in several ways. Slabs of sandstone are often found, as we have seen, with ripple marks as perfectly distinct as if it were moist sand that the water had washed an hour before.

On the wet sand of the shore many strange creatures, reptiles and birds especially, came in search of food cast up by the tide. They left distinct tracks in the sand, which caked in drying. The next tide would bring in more sand and spread it over these tracks, and this would happen again and again. When it all hardened and became stone, the footprints and ripples and rain-drops would remain unchanged; and when the sandstone was, ages and ages afterwards, broken with the pick, it would naturally split between the layers, and show the marks.

The first bird found in the rocks is a most wonderful creature. Near Munich, in Bavaria, there is a quarry of stone which is quite celebrated because the chalky slate taken out of it is used for lithographic engrav-

ings and chromos, and is perhaps the best in the world for that purpose. Slate, you know, splits in thin layers; this is partly because it was laid down by the

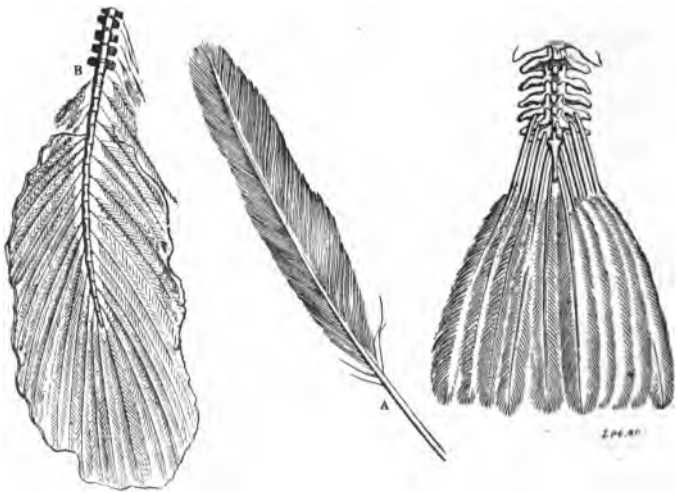


Fig. 81.—Tail and Feather of Reptile-like Bird, with Tail of Modern Bird for Comparison.

From Lyell's "Elements of Geology."

water, layer on layer, and partly also because it has been subjected to enormous pressure, and it splits in one direction, just as pie-crust does from the pressure of the rolling-pin.

In between two layers of this slate, about thirty years ago, a single but perfect feather was found (Fig. 81, A); this is the first trace of the earliest bird known. Soon another specimen was found; this was the hinder parts of a very strange creature, with tail feathers growing out of each side of a reptile-like tail. Figure

Fig. 82.—Skeleton in Stone of Reptile like Bird.

81, B, is the tail of the bird of the slate; C shows the tail of the birds we have now. You see how differently the feathers are attached. Some years later a slab of this same stone was found. A blow of the hammer and it fell open, showing, after careful working, bones, wings, tail, and head, which you see in Figure 82 just in the position in which they lay.

Several attempts have been made to draw the animal or bird to which this skeleton belonged. Figure 83 is one of these, and if you compare part by part you will see how closely the skeleton is followed. There is nothing to indicate that this curious creature had any feathers on its body. This is about as far from our idea of a bird as anything could well be, apart from its feathers and its legs. Notice the claws on the ends of the wings, its lizard-like head, arms, and teeth.

America has added of late years a large number of reptile-like birds. They come mainly from New Jersey and Kansas. Among them are waders, swimmers, and divers. Some of them were evidently flying birds, for they have the keel down the breastbone, which sustains the muscles of the wings. This keel you have often seen when the white meat is cut from a chicken

Fig. 83.—The Earliest Bird (*Archæopteryx*).
Restored by R. W. Shufeldt.

or turkey. Others, like the ostrich, which do not fly, but assist themselves with their small wings in running, have no keel. Six kinds of the American reptile-birds have teeth, a thing no living bird has nowadays. The two great branches of the reptile family were not then disentangled and separated from each other; so that the birds still had some things left from their reptile forefathers, and the reptiles had not lost certain other things which afterwards disappeared in their branch, but were kept and developed by the birds.

There are very few bird skeletons in the rocks—few even when compared with the bones of fish and reptiles. The reason of this is not far to seek. In our own times, when the woods are full of birds, many thousands must of course die every year, and yet who ever sees a bird skeleton after the feathers and flesh are gone? A large part of the bones of animals are gnawed by other creatures, broken up, or decayed, and so blow away and are lost. What is true of all wild creatures is especially true of birds. If they fall on land, they fare like everything else; but if they fall in the water, instead of sinking and being covered over, their feathers buoy them up, and keep them afloat till they are beaten about and destroyed. It was only

one bird, probably, in many hundreds of thousands that fell in the right place on the sand or mud at the water's edge, near enough to be covered by the next tide, but not near enough to be washed away; so we are rather fortunate in finding traces of so many of these delicate creatures in the rocks. As time went on, the birds lost more and more of their reptile features, and became gradually like the birds we now know, while the reptiles lost their bird-like qualities—all but the laying of eggs, which both do now.

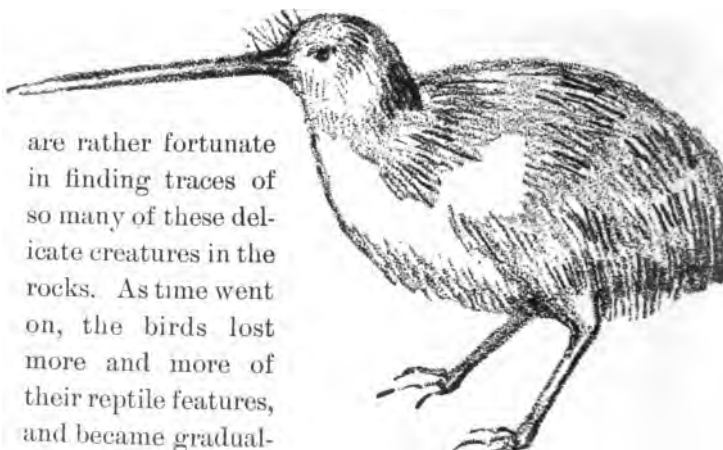


Fig. 84.—New Zealand Bird, lately extinct.

Although there is no time that could properly be called the reign of birds, there is one place that, when it was discovered by Europeans, might have received

justly the title of the Bird Kingdom: this is the island of New Zealand, near Australia. When it was first visited by white men not a single four-footed beast was found upon it, large or small. The highest form of life was the bird; and there were multitudes of these, closely allied to the birds of geology, with neither wings nor tails (Fig. 84); and great quantities of bird skeletons of gigantic size, some of them twelve or fourteen feet high. There are numbers of these skeletons at the Museum of Natural History, Eighty-second Street and Ninth Avenue, New York; also an egg which would contain as much as one hundred and fifty hen's eggs.

CHAPTER XXI.

THE REIGN OF LAND MONSTERS.

You remember, I hope, that the four-footed creatures had begun to come some time ago, when the chalk and limestone were forming at the bottom of the sea; but they were of a peculiar kind, like the kangaroo and opossum. These creatures are called marsupials, from a Latin word meaning bag or pouch, because the mother has on her body a sort of pocket or pouch, in which her tiny babies are put, and there they live till they open their eyes, and are strong enough to walk about alone.

One of the very largest land animals the world has ever known, it is believed from a bone lately found, belonged to the pouched animals. It was much larger than any living elephant, though looking like one, with great trunk and tusks (Fig. 85). It was related to other creatures that you have probably seen in a menagerie, the rhinoceros and tapir as well as the ele-

phant. One curious thing about the animals of these long-past days is that they are not like any of the living forms, but are connecting links between different kinds.

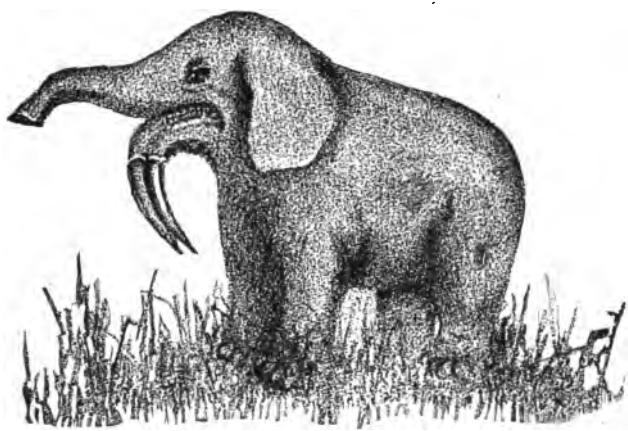


Fig. 85.—DINOTHERIUM.

The great four-footed beasts and the small ones are called mammals, because their young live upon mother's milk. Besides the land animals there are other mammals—whales and dolphins, seals and bats. The lowest order of the mammals are the marsupials, so they naturally were the first in the order of creation.

About a century ago Australia was scarcely known.

When it began to be settled by white men they found living in it very singular plants and animals, unlike those known in Europe. Very nearly at the same time that travellers were describing the curious life in Australia, geologists were studying the bones of very queer animals which had been dug up out of the earth; and it was discovered that Australian life was very much more like that which had been in Europe, thousands upon thousands of years before man came upon earth, than it was like anything then existing in the known world. In Australia there was not a single mammal higher than a marsupial, not a rat, nor a mouse, nor a rabbit; nothing but kangaroos and opossums and such creatures. It was, in fact, a young earth, not yet grown up; it had only reached the marsupial stage. America is young in the same sense, but not so young as Australia, while New Zealand is the youngest of the three. It has only grown up to the bird age. Of course, when these countries came to be settled by white people, plants and animals from Europe were introduced, and the changes which would have taken perhaps millions of years if left to natural causes were in this way greatly hurried.

The knowledge which went deeper into the earth,

geology, and the knowledge which spread wider over its surface, natural history, thus were found to confirm and explain each other.

I remember reading a long time ago, but I have never been able to find it since, that a singular bone found in the earth was taken to Richard Owen, the man who perhaps knew more about bones than any man of his day. After studying it carefully he said it belonged to a bird without wings or tail. In spite of his friends' advice to keep this quiet, as being probably incorrect, he published his views. These were soon after confirmed by the finding of a wingless, tailless bird in New Zealand. This is a good example of scientific guessing.

As we approach the coming of man upon the earth, we find all nature beginning to put on the look so familiar to us. The forests were made up of trees very like those we now know—oaks and elms, walnuts and birches, interspersed with pines and firs, yews and cypresses. The fields were covered with grass and flowers. On the surfaces of quiet ponds the water-lilies spread their broad leaves and opened their fragrant flower-cups, while underneath could be seen the delicate fronds and thread-like leaves of water-plants,

swaying back and forth with every gentle movement of the water. Mosses and liverworts clothed the damp rocks with a garment of living green. The trees and flowers of that day did not, in many cases, differ from ours; more than one kind of maple, for instance, differs from another (Fig. 86).

Fig. 86.—Maple Leaf.
From Lyell's "Elements of Geology."

The most interesting thing in the plant life of that day is the proof it gives of difference of climate from that which exists in the same parts of the world now. Mingled with the oaks and birches of our zone are great palms and tree-ferns, which now grow only in very hot countries. The cypresses and magnolias that to-day grow in the swamps of Carolina and Louisiana then grew in Greenland. There is strong reason to believe that America was joined with Europe on the east by way of Greenland, Iceland, and Norway, and that at the same time it was joined with Asia on the west across Behring Strait.

Among the shell-fish, oysters grew in great abundance and to great size, and the rivers were filled with eatable fish, shad and perch.

One very wonderful thing in that time was the myriads of insects that filled the earth and air. It would seem impossible that so delicate a thing as an insect could be kept in the rocks all these thousands of years in such a state that it could be recognized (Figs. 87 and 88), and yet this is true, not of one, but of hundreds of varieties. Uncounted millions of insects of various kinds perished, and are found packed in solid layers in the rocks. How this happened we may guess from something that Professor Le Conte tells us. He says that he has seen, after a storm, on the sands that border Lake Superior, millions of insects that had been drowned and washed ashore, till the banks were black with them. A layer of sand, washed up by

Fig. 87. — Insect found in Rock.

From Lyell's "Elements of Geology."

the beating waves, and deposited on top of these, would preserve them, as the insects of old were preserved.

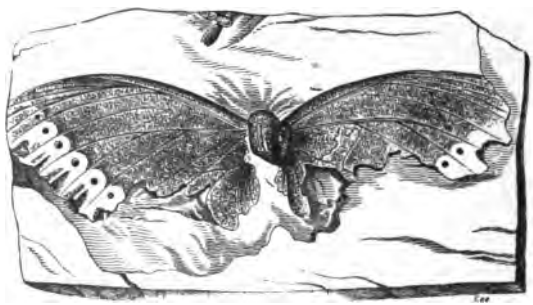


Fig. 88.—BUTTERFLY FOUND IN ROCK.
From Lyell's "Elements of Geology."

In the whole of Europe there are now only fifty species of ants known, but in a layer of rock in Switzerland one hundred species have been found, and these were all winged ants. In a colony of ants of our day there are at least three kinds of ants—males, females, and workers. The males and females have wings at first and the workers do not. When they settle down into nest life the males are left out; the females, or queens, unhook their wings, and become good mothers and home-keepers. The workers attend to the young,

keep the nest clean, and do all the work. But with the geologic ants all the members of the colony had wings. They probably lived a savage life of freedom, and were as improvident as the grasshoppers and butterflies of to-day.

The most perfect specimens we have are those flies and moths which were enclosed in amber. Amber is only fossil-tree gum. You have often seen a clear, sticky gum oozing out of cherry and peach trees. If you notice next summer you will very likely see some unfortunate insects that have alighted on the sticky stuff and are caught fast. The next gum that oozes out may roll over the poor little victim and enclose it. As long as the amber lasts, the insect enclosed will remain unchanged. Most of the fossil insects in amber are perfect, except their legs, which have been broken in the struggle to free themselves.

Enormous monsters roamed through the woods. Their habits, however, were generally less alarming than their looks, for most of them were herb-eating animals. Great sloths as large as an elephant, with terrible paws (Figs. 89 and 90) and gigantic tails, tore down the branches of trees or dug up eatable roots. The brains of these animals were small compared to

those of the same families nowadays, though the animals themselves were so much larger. There were, to be sure, some lions, tigers, and wolves roaming about in search of prey, but most of the animals were herb-eating, as are the largest of the beasts of the present day.

Fig. 89.—Skeleton of Megatherium.
From Hooker's "Mineralogy and Geology."

Among the quadrupeds we see the same approach to living forms. The forefathers of the horse, deer, antelope, elephant, rhinoceros, and tapir appear. The strange reptilian birds are gone, and in their places swallows are building in the crevices of the rocks; song-birds fill the forests with their happy voices; parrots call from one tree to be answered from another; cranes and flamingoes wade in the shallow wa-

Fig. 90.—Skeleton of Mylodon.
From Hooker's "Mineralogy and Geology."

ter, seeking their food; sand-grouse and the ancestors of our domestic fowls scratch around with their broods. All nature is making ready for man, who will appear in the next period of the world as the crown of the Creator's work.

CHAPTER XXII.

THE COMING OF MAN.

THE last period that belongs to geology was the most remarkable in the history of the earth for the great changes in the earth's crust, and in consequence of this, for its changes in climate.

During the early part of this period, for some unknown reason, certain parts of the continents lifted themselves up till they stood one or two thousand feet higher than they now stand. Later on, a sinking took place, which carried some parts of the continents as much as one thousand feet below where they are today, and after that they began again to rise till they reached very much their present level.

These movements caused, of course, an enormous alteration of climate, and the changes in vegetable and animal life which accompany variation in climate. There is still some movement going on; some parts of America are rising, while other parts are slowly sinking.

The parts of America and Europe that rose were all towards the north. The mountain chains there and the high plains all became covered with a thick sheet of ice, which moved, like the glaciers of Switzerland, to the lower land, grinding and wearing down the rocks over which they passed.

You may very naturally ask, How can we know that this all really happened? I want you to look back at the chapter on the work of the Ice-king. You will find there that all glaciers move, and as they move they take up pieces of broken rock in their way; these freeze into the under side of the moving ice, and scratch and score the bed-rock over which it passes, and polish off their own corners at the same time.

Strewed all over the northern part of our continent, on the tops of the hills as well as in the bottoms of the valleys, is a surface soil from thirty to three hundred feet deep. This soil is made up of stones, gravel, sand, and earth, which, you remember, is pulverized rock. The stones are irregular, but rounded on the corners, scratched, and worn exactly like the stones that are found beyond the end of a glacier. If you dig you will find the stones becoming more worn and scratched as you go down, and when you get to

the solid rock underneath it all, that too is scored and polished, *all in one direction*, as only a heavy body passing over it and grinding it down could do. The very top stones are neither scratched nor rounded, only those that have rubbed against one another in the movement of the glacier, or scratched against the bottom rock.

This is called the northern drift; and the writing upon the wall that terrified Belshazzar so, but which Daniel so easily read, was no clearer than the history of its progress which the long-vanished glacier has left written upon the rocks. If more proof were needed, it is here. These rocks lying loose mixed with the soil are not at all like the rock beneath. Sometimes, for instance, they will be blocks of granite, when the nearest granite bed-rock is a hundred miles away.

In the Southern States there is no such drift. The soil there is often mixed with stones, but they are neither scratched, nor scored, nor worn down, and they are usually exactly the same material as the rock underneath them.

By carefully examining the drift bowlders we find that in New England they have come from the rocks

of the far north-west; in Ohio, from due north; and in Iowa, from north-east; that is, the glaciers, on the testimony of the rocks, started from the high lands of British America, and spreading out both east and west, moved downward and outward in a fan shape towards the south. The distance travelled over by this sheet of ice was in some places only a few miles; in other places, some hundreds of miles.

These glaciers were not exactly like the Swiss glaciers, for they are formed and move in a warm climate, but they were like the glaciers of Greenland. This country, you know from your geographies, is a great peninsula in the north-eastern part of America. It is twelve hundred miles long by about five hundred miles wide; the whole country is covered with a great ice sheet more than a mile thick. This sheet moves southward and towards the sea, forced onward by the weight of snow and ice on the northern and high land part, which each winter's freeze makes heavier. The solid sheet only separates into distinct glaciers when it reaches the ocean. As these move off the coast, the waves wear them, and they finally break off, and with a thundering noise go splashing into the sea and float away as icebergs.

Just so New England, Ohio, Illinois, Indiana, and Iowa were covered with a great ice sheet that moved southward, scouring and polishing the bed-rock, and gouging out lake-beds. From its southern margin the ice sheet "stretched out icy fingers" down the valleys of the Hudson, the Susquehanna, and other rivers, and passed away as icebergs when they reached the sea.

After this came the time when the continents began to sink. Down, down they went, so slowly that we cannot conceive of it as motion, till the land lay in places two or three thousand feet below where it had been in the ice period, and one thousand feet below the present level. The water, of course, rushed in, filling the low lands, and turning them into lakes and inland seas. Above the drift there are plainly to be seen old lake-margins and signs of flood proving this point. Europe had very much the same experience as America in the rising and falling of certain parts of the continent.

During this age there were immense numbers of mammals. Their skeletons are to be found in old sea-beaches and lake-margins, where they were stranded and covered over with mud and sand; in marshes and

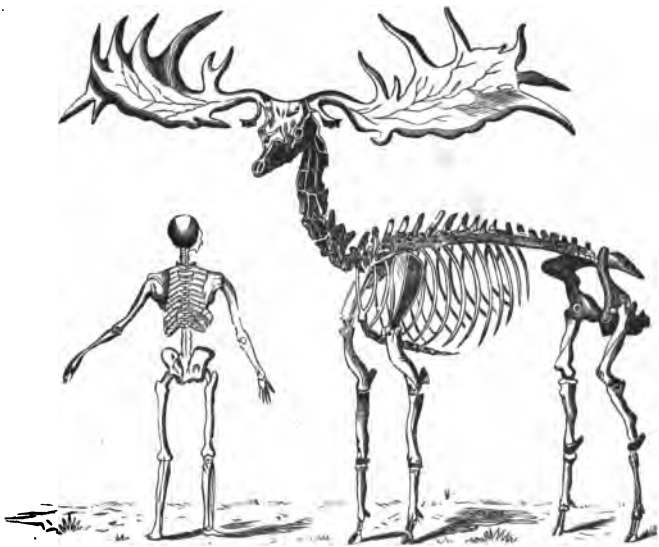


Fig. 91.—THE IRISH ELK COMPARED WITH MAN.
From Winchell's "Sketches of Creation."

bogs, where they had been mired when seeking for food, and preserved by the bog-water (Fig. 91); and in frozen ground and ice-banks, where some of them have been preserved to the present century.

Do you remember about the limestone caverns—great holes worn out in the midst of the rocks by the dripping water? Look back to Chapter III., at the

picture of Luray, if you have forgotten. These caves seem to have been the homes of myriads of animals at this time; hundreds of skeletons and bones are found in them—elephants and bears, elks, horses, and oxen, hyenas, lions, and tigers in a jumble, covered over with the stalagmites from the drippings of the cave. It is generally supposed, from the gnawed state of some of the bones, that these caves were the homes of the lions, bears, and hyenas, and that they dragged their prey in here to devour them. It may have been that others were washed in by the water which overlaid them in many cases with mud and sand.

The animals found in bogs were almost always herb-eating creatures, who evidently went there for food, and sank in and were drowned.

The most wonderful specimens which have been found belonging to this era were those that had been in some way enclosed in ice and frozen up, and have come down to modern times entire, not mere skeletons, but with flesh and skin, tusks and wool, all preserved. The creature so frozen up is called the hairy mammoth (Fig. 92), and this is the way he was found:

In 1799 an Asiatic chief, who used to collect the tusks found in the northern part of Siberia for sale,

Fig. 92.—THE HAIRY MAMMOTH.

From Winchell's "Sketches of Creation."

observed a queer dark mass in a block of ice. Each year on his hunts, as the ice broke away, he saw more and more of the body of a mammoth exposed; finally, at the end of five years, the ice melted so much that the body rolled out upon a sand-bank below. The hunter cut off the tusks, which he sold for about forty dollars. The animal was a mammoth, covered with

reddish wool and long coarse hair, and with a heavy mane. The flesh, after its burial in the ice for uncounted thousands of years, was fresh enough for the dogs to devour it eagerly. When it was found by Mr. Adams, who knew the value of the creature as a specimen, he says that the ground around it was trampled by the wild beasts—white bears, wolves, and foxes—which had come to feed upon the flesh. Mr. Adams got the bones out of the ice, bought back the tusks, and brought the whole thing over seven thousand miles to St. Petersburg, where its skeleton now is. He says he collected more than thirty-six pounds of hair and wool, which had been trampled into the ground by the animals that came to feed on the flesh. The skin still remains on its head, and some of the mane on its neck. Other specimens have been found in the ice, but this one is the best preserved.

The mastodon, another member of the elephant family, occurs in America. The mastodon was one of the two largest land animals; it was fourteen feet high, and twenty-five feet long, including its tusks. Along with these mighty elephants and the cave animals man appeared upon the earth (Fig. 93). He may have come earlier, but that is not perfectly certain. In the

Fig. 93.—PREHISTORIC MAN.

From Winchell's "Sketches of Creation."

caves human bones are mixed with those of the cave lion and bear; together they have been covered over and preserved. Stone implements, and piles of what are called *kitchen-middens*, also occur: these are refuse of food, piles of oyster-shells that have been opened, and other things that prove conclusively that they are the work of men.

But the strongest proof of all that human beings lived at the same time as the cave animals and mammoths is that in a cave in France several smooth pieces of bone, with rough pictures of the animals scratched upon them with some sharp-pointed instrument, have been found. In Figure 92 you see such a picture of the mammoth drawn by primeval or early man.

This age I have called the Coming of Man, and not the Reign of Man. He has only appeared upon the scene, but he has not yet gained the mastery over the brutes; he is still a savage, with only the rudest and simplest arts, but he is a man—as truly a member of the human race as any who have come after him. But it is as the promise of the reign to come that he means anything, rather than that he is, for some time to come, to be fully established as the lord of creation.

THE END.

Roddy's Geographies

Elementary Geography. Price 50 Cents

Complete Geography. - - Price $1.00

By H. JUSTIN RODDY, M.S.

Department of Geography, First Pennsylvania State Normal School

---

THIS SERIES has been prepared to meet a distinct demand for new geographies which are thoroughly up to date and adapted for general use in ordinary schools rather than for a particular use in a highly specialized and organized ideal system.

They are distinctive in the following important particulars:

1. An adequate amount of material is included in each book to meet the needs of those grades for which it is designed.

2. The subject-matter is presented so simply that the pupil can readily understand it, and so logically that it can be easily taught by the average teacher.

3. Just enough physiography is included to develop the fundamental relations of geography and to animate and freshen the study without overloading it in this direction.

4. The simplicity of the older methods of teaching this subject is combined with just so much of the modern scientific methods of presentation as is thoroughly adapted to elementary grades.

5. The illustrations are new and fresh, reproduced mostly from photographs collected from all parts of the world with a view to helping out and explaining the text and not for mere embellishment.

American Book Company, Publishers

(S. 110)

BAIRD'S GRADED WORK IN ARITHMETIC

First Year - - -	Boards, $0.18;	Cloth, $0.20
Second Year - -	" .18;	" .20
Third Year - - -	" .20;	" .25
Fourth Year - -	" .20;	" .25
Fifth Year - - -	" .20;	" .25
Sixth Year - - - - - - - - -		" .25
Seventh Year - - - - - - - -		" .25
Eighth Year - - - - - - - -		" .25
Practical Arithmetic for Grammar Grades		" .65

BAIRD'S Graded Work in Arithmetic consists of eight books, designed for use in elementary grades. The series furnishes text-books carefully planned to strengthen the powers of mathematical reasoning, at the same time presenting a range of topics sufficiently comprehensive to familiarize pupils with the important practical applications of the science to the wants of common life. The Practical Arithmetic is designed for general use in grammar grades, and, with the first four books, forms a five-book series.

The books represent the latest and best methods of teaching arithmetic. They abound in combinations of oral and written work, and in copious examples for drills and reviews. The subjects are taken up alternately, in accordance with the ability of the child, in this way following the so-called "spiral system." Great care has been taken in the selection of illustrative examples and operations. Explanations and analyses have been given in full.

AMERICAN BOOK COMPANY

Maxwell's English Series

WILLIAM H. MAXWELL, M.A., Ph.D.,
Superintendent of Schools, City of New York.

First Book in English	40 cents
Introductory Lessons in English Grammar .	40 cents
Advanced Lessons in English Grammar .	60 cents
Maxwell & Johnston's School Composition .	50 cents
Maxwell & Smith's Writing in English . .	75 cents

The **First Book in English** combines lessons, practice, and instruction in the elementary principles in the English language in a rational and practical way.

The **Introductory Lessons** presents as much of the science of grammar with its applications as children can understand and appreciate before taking up advanced work.

The **Advanced Lessons** embraces all the *theory* and all the *practice* that are necessary during the last two years of a grammar-school or throughout a high school course.

The **School Composition** is inductive in plan, and correspondingly helpful. The topics suggested for compositions are those which will appeal to children.

Writing in English is intended for advanced grades. It takes up first entire compositions, next paragraphs, then sentence construction, and finally words. A special feature is the large number and practical character of the exercises.

AMERICAN BOOK COMPANY

(S. 78)

Historical Readings for the Young

EGGLESTON'S STORIES OF GREAT AMERICANS FOR LITTLE AMERICANS . . . . . 40 cents

For Second Reader Grade. Its primary aim is to provide reading lessons that will excite attention and give pleasure, and thus make the difficult task of learning to read easier. Another purpose is to interest children at an early age in the history of our country by making them familiar with its great characters and leading events. This is most effectively done in this little book by entertaining and instructive stories which every American child ought to know, and by vivid descriptions of scenes and incidents which pertain very largely to the childhood of the great actors represented.

EGGLESTON'S STORIES OF AMERICAN LIFE AND ADVENTURE . . . . . 50 cents

For Third Reader Grade. It includes reading matter that is intensely interesting to the young—stories of Indian life, of frontier peril and escape, of pioneer adventure and Revolutionary daring, of dangerous voyages, explorations, etc. With these are interspersed sketches of the homes and firesides, the dress and manners, the schools and amusements of the early colonial and pioneer periods. The stories of this book represent in a general way every section of our country and every period of its history.

Copies sent, prepaid, on receipt of the price.

American Book Company

NEW YORK • CINCINNATI • CHICAGO

(S. 27)

Herrick, S.B.

The earth in past ages.

NAME	DATE	NAME	DATE